

POWER/VAC® **Metalclad Switchgear** **Application Guide**



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POWER/VAC[®]
Metalclad Switchgear
Application Guide

DEDICATED to the team of product planners, design and manufacturing engineers, application and system engineers, and department management that conceived and developed the new POWER/VAC Switchgear. This new equipment, as a distinct advancement in applied switchgear technology, will more effectively and economically serve the needs of the electrical power industry.

POWER/VAC[®] **Metalclad Switchgear** **Application Guide**

Published by the
Switchgear Business Department
General Electric Company

Information contained in this Application Guide is based on established industry standards and practices. It is published in the interest of assisting power system planners and engineers in the preparation of their plans and specifications for medium-voltage metalclad switchgear. Neither the General Electric Company nor any person acting on its behalf assumes any liability with respect to the use of, or for damages or injury resulting from the use of any information contained in this Application Guide. The information in this guide does not supplement or replace performance data contained in other product publications of the Company.

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Foreword

USE OF APPLICATION GUIDE

This *Application Guide* provides information necessary to help plan and specify medium-voltage power system switchgear, using General Electric's new POWER/VAC[®] vacuum metalclad switchgear. This guide is organized to present the switchgear application procedure in an orderly, step-by-step manner. Since it is intended to be a workbook, only the data necessary to choose applicable switchgear is included.

Complete specifications can be written for most switchgear applications using this publication, a system one-line diagram, and reference to appropriate literature for guidance in calculating short-circuit currents or for other extensive technical information beyond the usual scope of an application guide.

The topics discussed in the first five sections of this guide are of a general nature, applicable to any type of medium-voltage metalclad switchgear. Information is provided relating to one-line diagrams, circuit breaker ratings and selection, control power requirements, basic circuit protection considerations, and specific recommendations for protection, instrumentation, and control for basic switchgear circuits.

The remainder of the application guide explains the application and specification of General Electric POWER/VAC metalclad switchgear. The concepts of modular construction and device package structuring are basic to POWER/VAC switchgear and are introduced and illustrated through application details covering the use of POWER/VAC breakers in basic circuit applications. Auxiliary unit and power conductor compartment structuring are also included. Following the selection of individual units, an optimum lineup configuration can be developed using the guidelines given. Finally, a specification procedure, complete with Guide Form Specifications, is suggested to facilitate the documentation of POWER/VAC metalclad switchgear requirements.

This approach to metalclad switchgear application is typical and its use is recommended. Where practical, begin with Section 2 and work through the guide in a step-by-step fashion. The guide's structure is based on extensive engineering experience and will serve as a checklist which will aid in preparing complete specifications.

Since the application of POWER/VAC metalclad switchgear is the underlying purpose of this guide, a brief introduction to POWER/VAC will serve as a useful starting point to begin the application procedure.

POWER/VAC METALCLAD SWITCHGEAR

POWER/VAC metalclad switchgear is designed for application on 5-kV, 7.2-kV, and 15-kV power systems with available short-circuit capacities from 250 through 1000 MVA nominal. A typical 10-unit lineup of indoor POWER/VAC switchgear is shown in Figure 1-1.

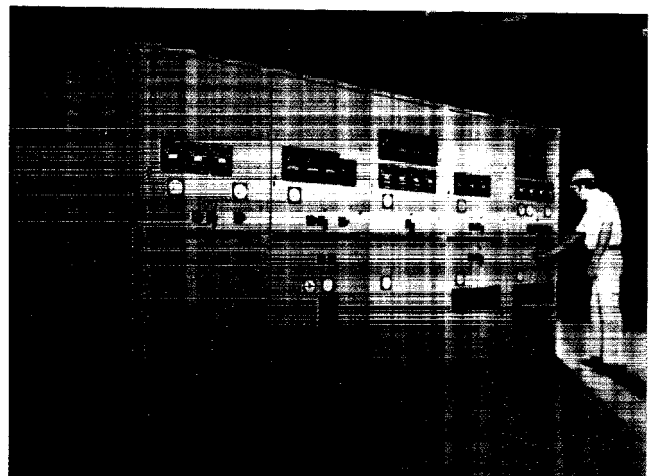


Figure 1-1. Typical 10-unit lineup of indoor POWER/VAC switchgear.

POWER/VAC circuit breakers are rated per ANSI C37.06-1971, Table 2. Available ratings are shown on page 3-3 of this application guide.

POWER/VAC switchgear is designed, built, and tested to the applicable industry standards shown in Table 1-1.

POWER/VAC equipment is furnished in four basic types: indoor, minimum outdoor (no aisle), protected-aisle outdoor, and common-aisle outdoor (aisle shared by two facing lineups). Figure 1-2 shows typical section outlines for each of the basic equipment types. Dimensions and weights are shown in Section 8.

Table 1-1. Applicable Industry Standards

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI) 70 East 45th Street New York, New York 10017		NATIONAL ELECTRICAL MANUFACTURERS ASS'N (NEMA) 155 East 44th Street New York, New York 10017	
Standard No.	Description	Standard No.	Description
C37.04	AC Power Circuit Breaker Rating Structure	SG-2	High-voltage Fuses
C37.06	Preferred Ratings of Power Circuit Breakers		
C37.07	Interrupting Factors — Reclosing Service	SG-4	Power Circuit Breakers
C37.09	Test Procedure for Power Circuit Breakers		
C37.010	Application Guide for Power Circuit Breakers	SG-5	Power Switchgear Assemblies
C37.11	Power Circuit Breaker Control Requirements		
C37.20	Switchgear Assemblies and Metal-Enclosed Bus		
C37.100	Definitions for Power Switchgear	SG-6	Power Switching Equipment

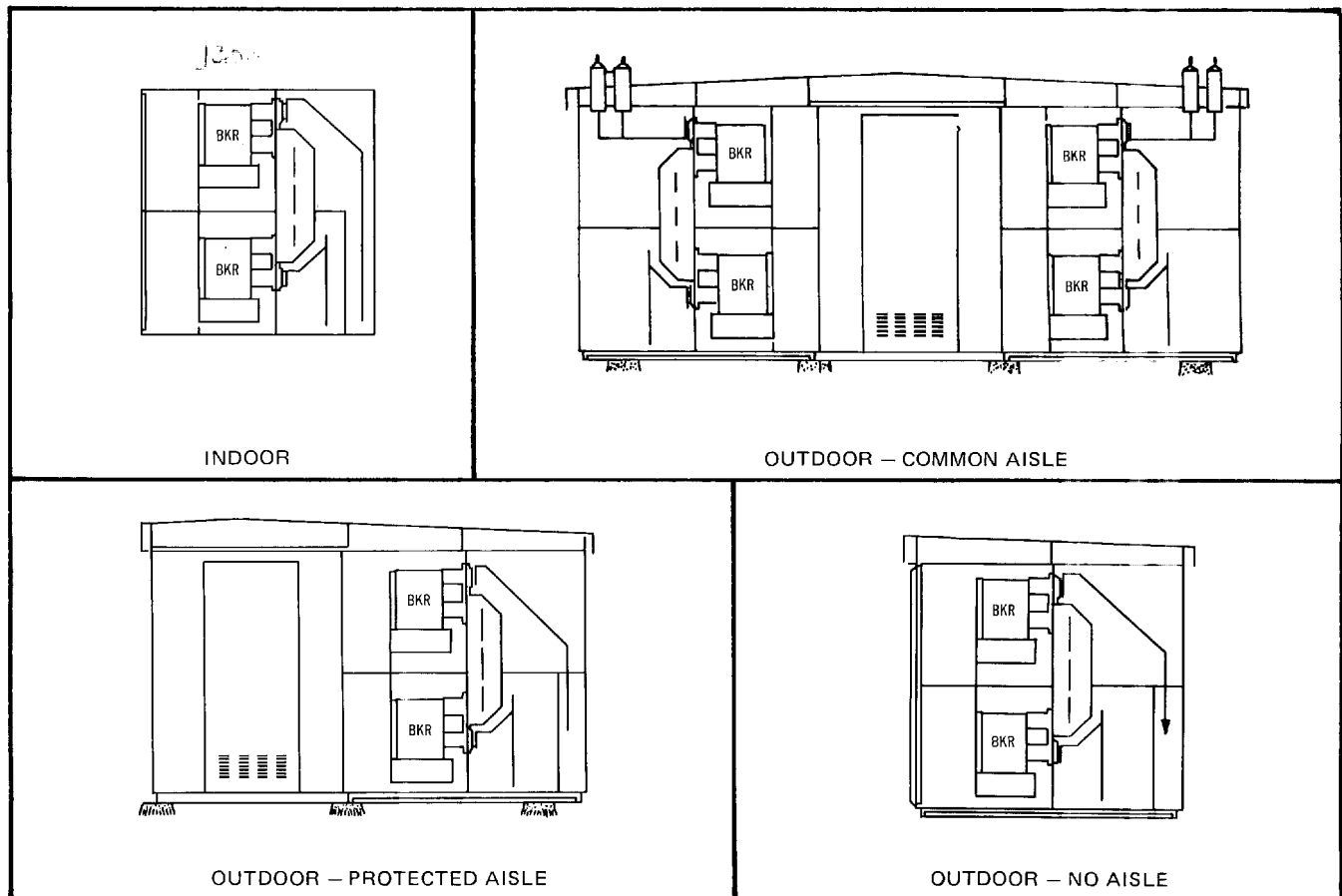


Figure 1-2. Typical section outlines.

General Electric's POWER/VAC metalclad switchgear combines the advantages of metalclad construction — safety, flexibility, and economy — with the benefits of vacuum interrupters — reliability, low maintenance, and reduced breaker size and weight.

Specifically, POWER/VAC switchgear incorporates the following new basic design elements, compared to air-magnetic and early designs of vacuum metalclad switchgear.

- POWER/VAC offers two-tier breaker stacking for application flexibility and floorspace savings.
- POWER/VAC utilizes modular construction resulting in one basic vertical section size, thus simplifying system planning and providing installation savings.
- POWER/VAC features structured protection, instrumentation, and control (PIC) packages for most switchgear applications, minimizing planning and engineering time.

These fundamental design improvements affect certain elements in the switchgear application procedure, principally the one-line diagram and the arrangement of switchgear units in a lineup. Since these application considerations are a result of the equipment design, a brief illustration of POWER/VAC switchgear design concepts is provided.

TWO-TIER BREAKER STACKING

Mixing and matching of a variety of unit types and breaker ratings is possible using two-tier unit stacking. The nine standard combinations of upper and lower units are shown in Figure 1-3.

MODULAR CONSTRUCTION

Breakers and auxiliary devices can be accommodated in the upper and lower breaker compartments as shown in Figure 1-4. Typical equipment section views in Figure 1-5 illustrate how upper and lower units can be combined.

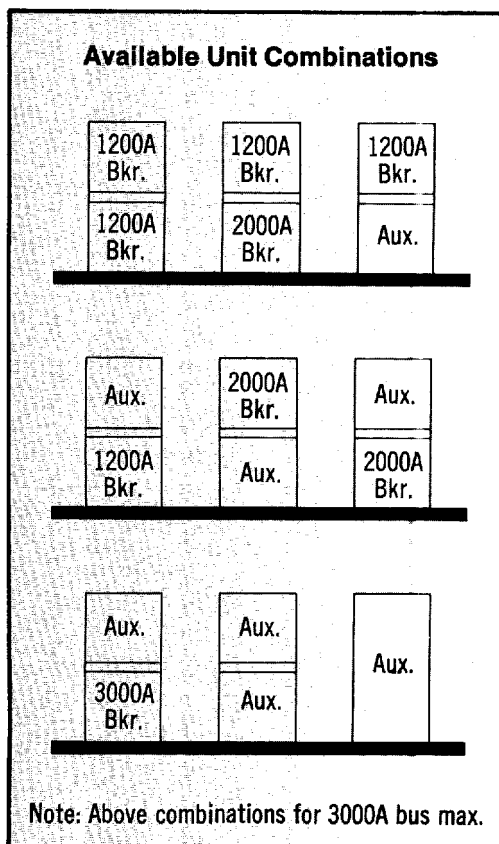


Figure 1-3. Nine standard combinations of upper and lower units.

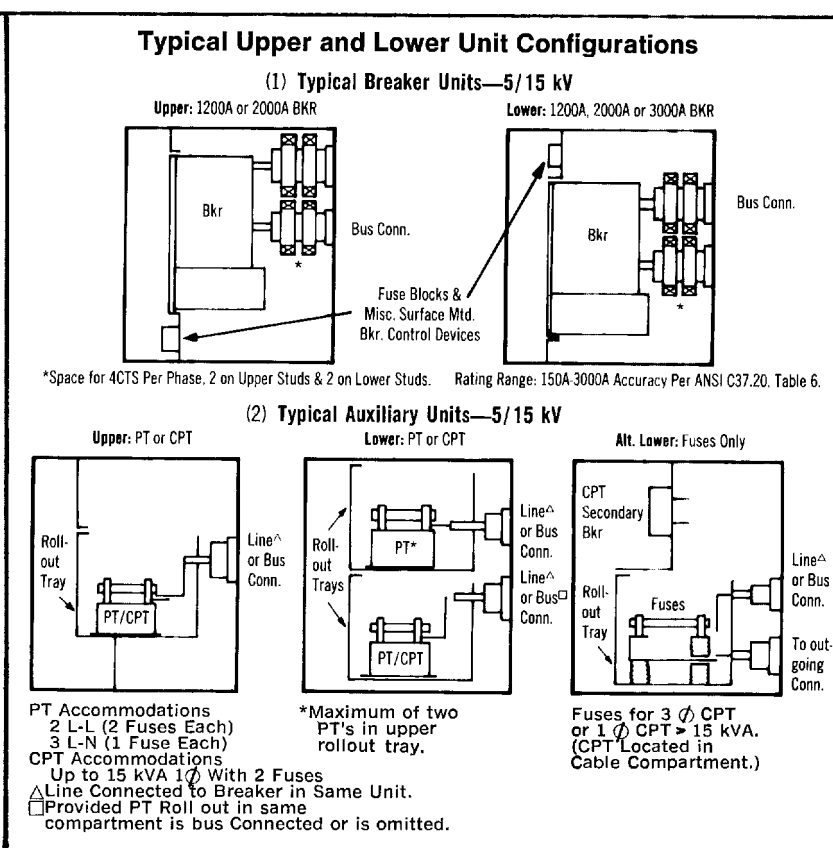
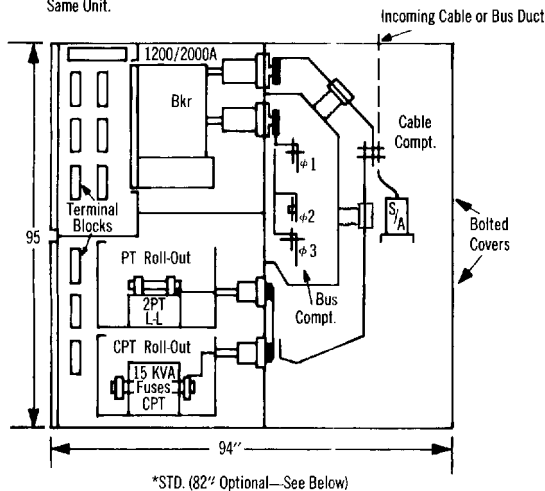


Figure 1-4. Typical upper and lower unit configurations.

Typical Equipment Section Views

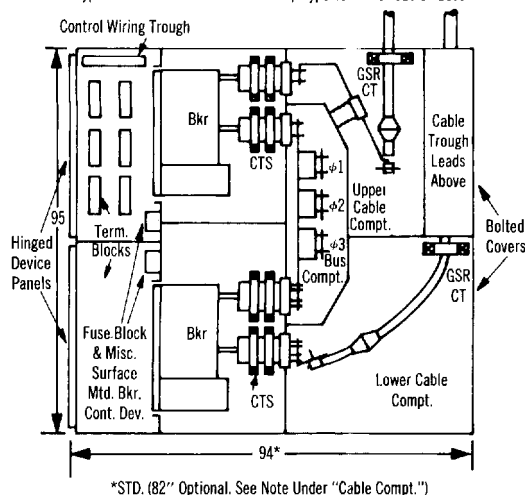
Typical Incoming Line Unit With Main Breaker & CPT & PT Roll-outs in Same Unit.



CABLE COMPARTMENT

- Designed for up to 2-750 MCM/φ per breaker; cables above or below.
- CT's with greater than ANSI accuracy must be mounted in cable compartment and may limit such cases to one breaker per vertical section.
- Stress cone space of 21 inches is provided and use of preformed stress cones, such as GE Termimatic (TM), is recommended.
- * Certain simple cable compartment configurations such as clamp type terminations for one moderate-sized cable per phase, with or without Ground Sensor, permit a unit depth of 82 inches on indoor units.

Typical 2 Bkr. Feeder Unit with Clamp Type Term. For Cable Above.



BUS COMPARTMENT

- 1200A and 2000A: Aluminum standard; copper optional.
- 3000A bus is copper only.
- Bus supports designed for 80,000A momentary.
- All joints connected with 2 bolts and booted.
- Bus support insulation system:
Non-tracking polyester glass (std. 5 kV)
Porcelain inserts (std. 15 kV)
Fluidized bed exopy bus insulation.

Figure 1-5. Possible combinations of upper and lower units.

PIC PACKAGES

Pre-engineered PIC packages (Protection, Instrumentation, and Control) complement POWER/VAC structured equipment and breaker designs. A PIC package for application on a general-purpose feeder is shown in Figure 1-6. Structured PIC packages contain all door-mounted devices such as relays, switches, meters, and instruments, and all non-door-mounted devices such as fuses, current transformers, and potential transformers that are required for proper circuit operation in a wide variety of basic switchgear applications. Because PIC packages are pre-engineered, the specific devices included in the material list are provided, and they are located exactly as shown in Figure 1-6.

SUMMARY

In summary, POWER/VAC switchgear differs in design and construction from traditional single-breaker, air-magnetic, and vacuum switchgear designs. From an electrical standpoint, however, the application procedures and guidelines for POWER/VAC are identical to those for other types of metalclad switchgear. This guide provides direction for proper application of POWER/VAC switchgear.

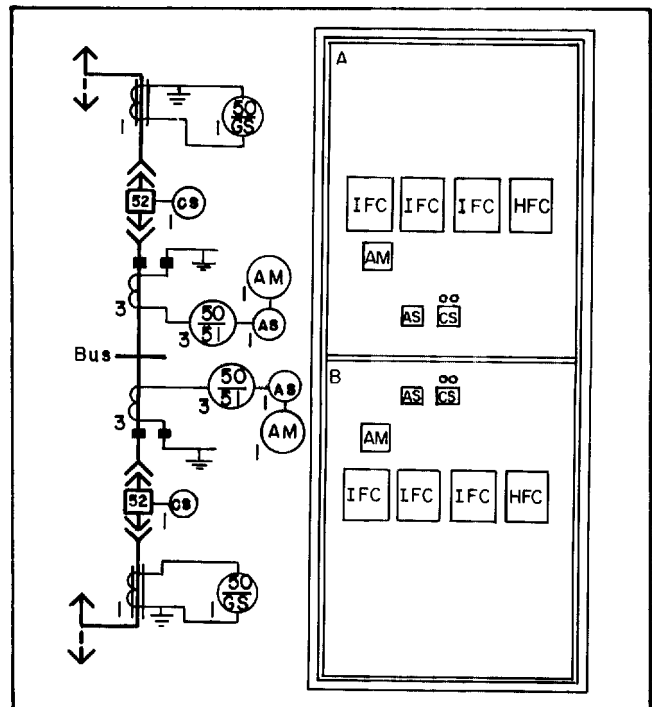


Figure 1-6. PIC package application on a general purpose feeder.

Section 2

System One-Line Diagram

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System One-Line Diagram

INTRODUCTION

The first step in preparing a specification for metalclad switchgear is to develop a one-line diagram. A one-line diagram (single-line) is "a diagram that shows, by means of single line and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein". (See Ref. 1 of this section.)

When preparing switchgear one-line diagrams, use graphic symbols in accordance with IEEE and

ANSI standards listed in References 2 and 3.

One-line diagrams employ device function numbers which, with appropriate suffix letters, are used to identify the function of each device in all types of partially automatic, fully automatic, and in many types of manual switchgear. A complete list of such device function numbers is published in Reference 4 and shown in Table 2-2.

DEVELOPING A ONE-LINE DIAGRAM

To illustrate the development of a one-line diagram, a typical resistance grounded system has been chosen. The same general procedures would apply to solidly grounded distribution systems.

Three steps are used in producing a one-line diagram: the preliminary diagram, followed by the partially developed diagram, and finishing with the developed diagram.

The abbreviations used for the principal meters, instruments, and other devices (not including relaying, which is listed in Table 2-2), as found in the application guide, are listed in Table 2-1.

Each device in an automatic switching equipment has a device function number which is placed

adjacent to or within the device symbol on all wiring diagrams and arrangement drawings so that its function and operation may be readily identified.

These numbers are based on a system which was adopted as standard for Automatic Switchgear by the American National Standards Institute and appear in ANSI C37.2-1970. (See Ref. 4 of this section.)

Table 2-2 is a list of device numbers and functions as taken from this standard.

Table 2-1. Abbreviations

Abbr.	Description	Abbr.	Description
AM	Ammeter	S	Synchronous motor
AS	Ammeter switch	S/A	Surge arrester
Aux	Auxiliary	SS	Synchronizing switch
Bkr	Breaker	SYN	Synchroscope
CO	Cut off switch	SYN BR	Synchronizing bracket
CPT	Control power transformer	TD	Test device
CS	Control switch	VAR	Varmeter (one-line)
CT	Current transformer	VARM	Varmeter (device list)
FA	Field ammeter	VM	Voltmeter
FM	Frequency meter	VR	Voltage regulator
G	Generator	VS	Voltmeter switch
GS	Governor Switch	WHM	Watthour meter
I	Induction motor	WHDM	Watthour demand meter
PT	Potential transformer	WM	Wattmeter

Table 2-2. ANSI Standard Device Function Numbers

Dev. No.	Function	Dev. No.	Function
1	Master Element	51	AC Time Overcurrent Relay
2	Time-Delay Starting or Closing Relay	52	AC Circuit Breaker
3	Checking or Interlocking Relay	53	Exciter or DC Generator Relay
4	Master Contactor	54	Reserved for future application
5	Stopping Device	55	Power Factor Relay
6	Starting Circuit Breaker	56	Field Application Relay
7	Anode Circuit Breaker	57	Short-Circuiting or Grounding Device
8	Control Power Disconnecting Device	58	Rectification Failure Relay
9	Reversing Device	59	Overvoltage Relay
10	Unit Sequence Switch	60	Voltage or Current Balance Relay
11	Reserved for future application	61	Reserved for future application
12	Over-Speed Device	62	Time-Delay Stopping or Opening Relay
13	Synchronous-Speed Device	63	Pressure Switch
14	Under-Speed Device	64	Ground Protective Relay
15	Speed or Frequency Matching Device	65	Governor
16	Reserved for future application	66	Notching or Jogging Device
17	Shunting or Discharge Switch	67	AC Directional Overcurrent Relay
18	Accelerating or Decelerating Device	68	Blocking Relay
19	Starting-to-Running Transition Contactor	69	Permissive Control Device
20	Electrically Operated Valve	70	Rheostat
21	Distance Relay	71	Level Switch
22	Equalizer Circuit Breaker	72	DC Circuit Breaker
23	Temperature Control Device	73	Load-Resistor Contactor
24	Reserved for future application	74	Alarm Relay
25	Synchronizing or Synchronism-Check Device	75	Position Changing Mechanism
26	Apparatus Thermal Device	76	DC Overcurrent Relay
27	Undervoltage Relay	77	Pulse Transmitter
28	Flame Detector	78	Phase-Angle Measuring or Out-of-Step Protective Relay
29	Isolating Contactor	79	AC Reclosing Relay
30	Annunciator Relay	80	Flow Switch
31	Separate Excitation Device	81	Frequency Relay
32	Directional Power Relay	82	DC Reclosing Relay
33	Position Switch	83	Automatic Selective Control or Transfer Relay
34	Master Sequence Device	84	Operating Mechanism
35	Brush-Operating or Slip-Ring Short-Circuiting Device	85	Carrier or Pilot-Wire Receiver Relay
36	Polarity or Polarizing Voltage Device	86	Locking-Out Relay
37	Undercurrent or Underpower Relay	87	Differential Protective Relay
38	Bearing Protective Device	88	Auxiliary Motor or Motor Generator
39	Mechanical Condition Monitor	89	Line Switch
40	Field Relay	90	Regulating Device
41	Field Circuit Breaker	91	Voltage Directional Relay
42	Running Circuit Breaker	92	Voltage and Power Directional Relay
43	Manual Transfer or Selector Device	93	Field-Changing Contactor
44	Unit Sequence Starting Relay	94	Tripping or Trip-Free Relay
45	Atmospheric Condition Monitor	95	Used only for specific applications in individual installations where none of the assigned numbered functions from 1 to 94 are suitable.
46	Reverse-Phase or Phase-Balance Current Relay	96	
47	Phase-Sequence Voltage Relay	97	
48	Incomplete Sequence Relay	98	
49	Machine or Transformer Thermal Relay	99	
50	Instantaneous Overcurrent or Rate-of-Rise Relay		

System One-Line Diagram

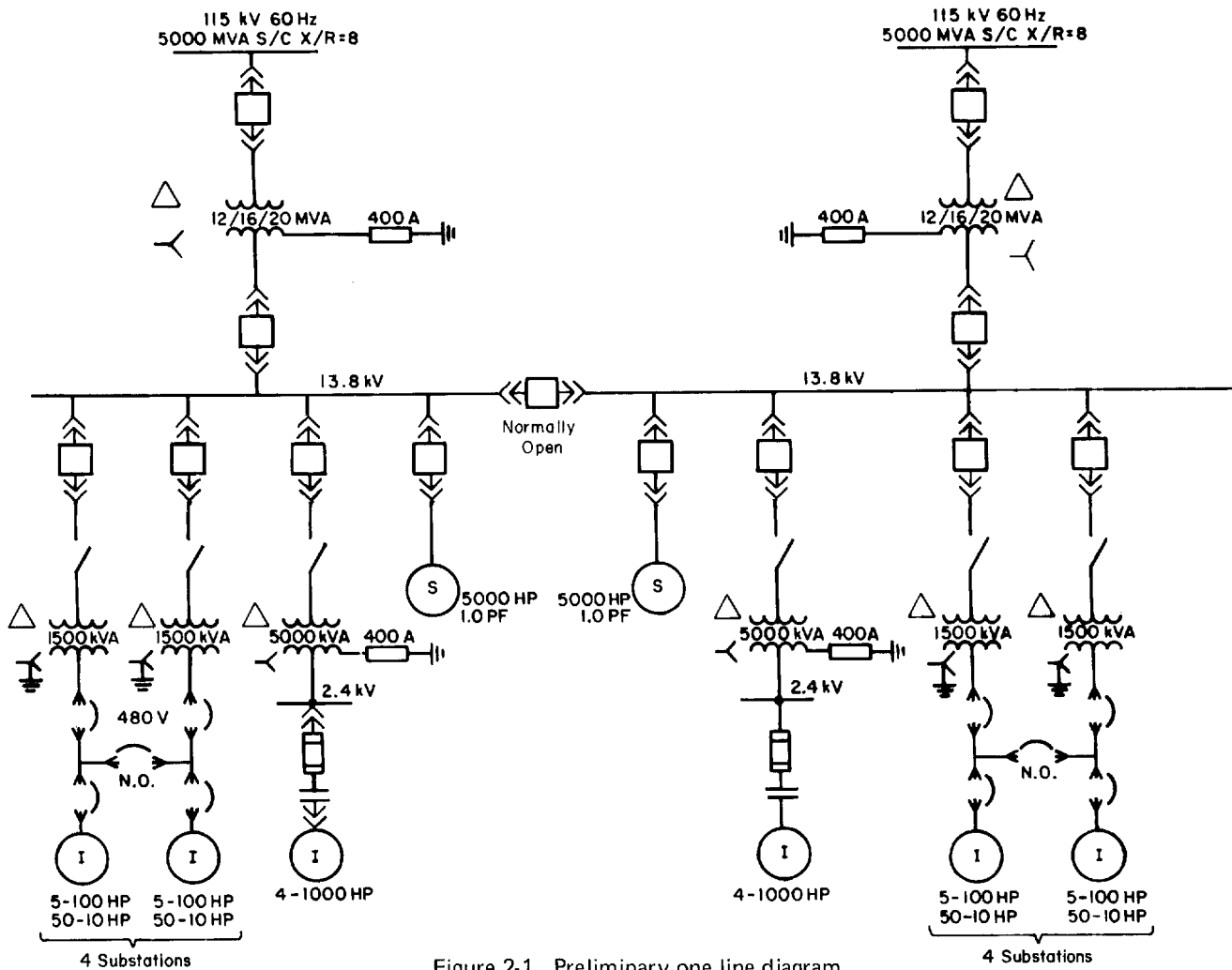


Figure 2-1. Preliminary one-line diagram.

PRELIMINARY ONE-LINE DIAGRAM

On this diagram (Figure 2-1) show:

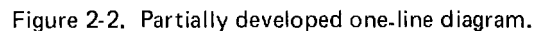
- System voltage and major component ratings.
- Major medium-voltage cable lengths, sizes, and construction. (Not shown in example.)
- Approximate number and ratings of all motors.
- Supply system available short-circuit capability in symmetrical MVA (plus X/R ratio) or per unit $R + jX$ (on a given base).

Using data on the one-line diagram, perform short-circuit calculations. (See Ref. 5 of this section.) From these calculations:

- Compare the calculated "first cycle" (momentary) asymmetrical current duty with the close and latch circuit breaker capability.

- Compare the calculated "1-1/2 to 4-cycle" (interrupting) current duty with the circuit breaker symmetrical interrupting capability. (See Ref. 3 of Section 3.)
- Determine the applicable circuit breaker ratings.
- Compare the feeder cable short-circuit heating limit with the maximum available short-circuit current times K_t times K_o . (See Ref. 10 and 12 of this section.)

Note that the calculations performed in accordance with Reference 5 determine only medium- and high-voltage circuit breaker ratings. Perform short-circuit studies to determine relay operating currents in accordance with procedures outlined in Reference 6. For other than power circuit breakers, refer to the appropriate ANSI standard for short-circuit calculation procedure.



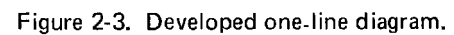
- Show ratings selected for external devices, such as grounding resistors, control power transformers, and batteries.
- Select tentative current transformer (CT) ratios in considering the maximum transformer ratings, motor ratings, and ampacity of the circuits involved. (See Section 5.)
- Locate current transformers and potential transformers, considering the type of protective relaying instrumentation and metering required.



- Show all relaying, instrumentation, and metering.
- Select relaying, instrumentation, and metering using the information given in Sections 5 and 6 of this Application Guide.
- Confirm the selection of relay ratings and

- Include in the study an examination of all circuits for compliance with applicable local and national codes. (See Ref. 11 of this section.)
- Verify that all circuit conductors are applied within the conductor short-circuit heating limit. (See Ref. 10 and 12 of this section.)

2-6



2-7

System One-Line Diagram

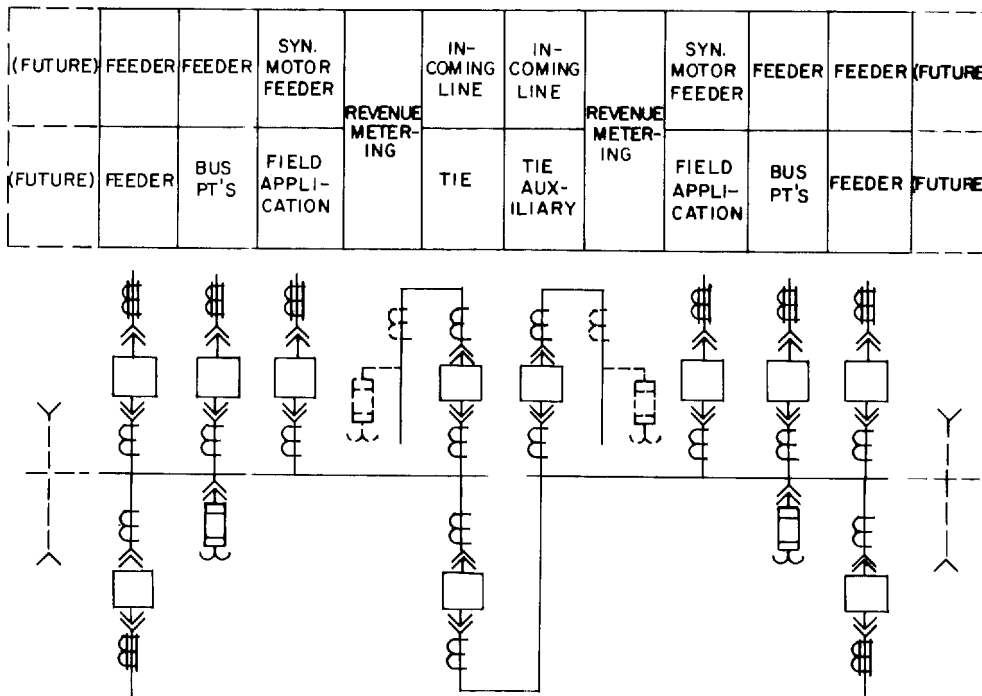
ADAPTING ONE-LINE DIAGRAM TO EQUIPMENT

Figure 2-4 shows two possible arrangements of POWER/VAC metalclad switchgear as developed from the one-line diagram in Figure 2-3. Both save space when compared to air-magnetic metalclad switchgear, and both permit the addition of future units on either end.

The arrangements shown are not the only ones which can be developed to satisfy the conditions of the one-line diagram. Use the information in Section 6 to adapt the one-line diagram to the equipment and develop a suitable arrangement for the particular installation.

Refer to Section 11 for a Bill of Material, Front View Arrangement, and Floor Plan for "Arrangement 2" of Figure 2-4. The information in Section 11 is typical of proposal information supplied for POWER/VAC switchgear.

ARRANGEMENT 1



ARRANGEMENT 2

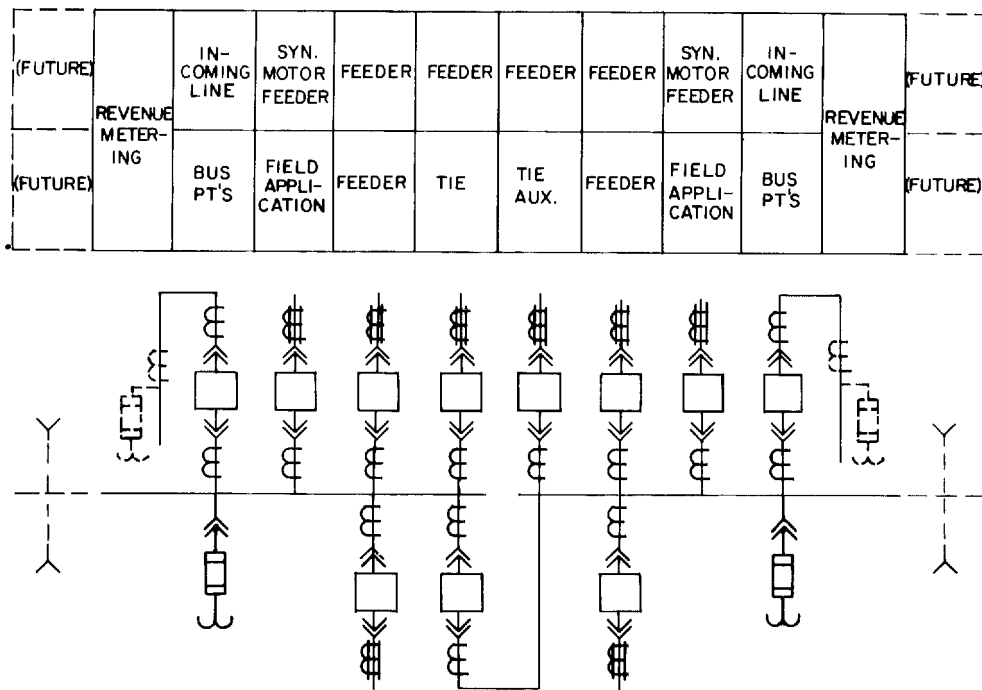


Figure 2-4. Two possible arrangements of POWER/VAC metalclad switchgear.

System One-Line Diagram

REFERENCES

Standards

	ANSI Standard	IEEE Standard	Title
1.	C42.100-1972	100-1972	IEEE Standard Dictionary of Electrical and Electronic Terms.
2.	Y32.2-1975	315-1975	Graphic Symbols for Electrical and Electronic Diagrams.
3.	Y14.15-1966 (R1973)	—	Electrical and Electronics Diagrams.
4.	C37.2-1970	—	Manual and Automatic Station Control, Supervisory, and Associated Telemetering Equipments.
5.	C37.010-1972	320-1972	Application Guide for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis.
6.	C37.95-1974	357-1973	IEEE Guide for Protective Relaying of Utility-Consumer Interconnections.
7.	—	141-1969	Electric Power Distribution for Industrial Plants.
8.	—	142-1972	IEEE Recommended Practice for Grounding of Industrial and Commercial Power Systems.
9.	—	241-1974	IEEE Recommended Practice for Electric Power Systems in Commercial Buildings.
10.	—	242-1975	IEEE Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems.

Codes

11. 1975 National Electrical Code — NFPA Publication 70-1975.

Books

12. Industrial Power Systems Handbook — D. L. Beeman, Editor McGraw-Hill Book Co., 1955.

Publications

13. GEA-10049 — POWER/VAC Metalclad Switchgear.

Standards may be purchased from:

American National Standards Institute, Inc.
1430 Broadway
New York, NY 10018

Institute of Electrical and Electronics Engineers, Inc.
Service Center
445 Hoes Lane
Piscataway, NJ 08854

National Electrical Manufacturers Association
Publication Department
155 East 44th Street
New York, NY 10017

National Fire Protection Association
470 Atlantic Avenue
Boston, MA 02210

Section 3

Circuit Breaker Selection

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Circuit Breaker Selection

INTRODUCTION

A circuit breaker's function and intended use are established in ANSI-C37.100-1972, Definitions for Power Switchgear, which defines a circuit breaker as:

"A mechanical switching device, capable of making, carrying, and breaking currents under normal circuit conditions and also, making, carrying for a specified time and breaking currents under specified abnormal circuit conditions such as those of short-circuit."

In addition, it is noted that a circuit breaker is intended usually to operate infrequently, although some types are suitable for frequent operation.

A circuit breaker is applied generally to carry and switch load current and to interrupt short-circuit current when required. The application process is simple: each of the duty requirements is specified or calculated and is then compared to the corresponding capability of the circuit breaker. The fundamental rule for selection of the proper circuit breaker is that the ratings or related capabilities of the circuit breaker must equal or exceed each of the calculated or specified duty requirements of the circuit in which it is applied.

Circuit characteristics which must be defined and compared to the circuit breakers' capabilities (given in Table 3-1) are:

- Circuit voltage
- System frequency
- Continuous current
- Short-circuit current
- Closing and latching current

In addition, certain special application conditions can influence circuit breaker selection. Special applications include the following:

- Repetitive switching duty (except arc furnace)
- Automatic reclosing
- Arc furnace switching
- Reactor switching
- Capacitor switching
- Fast bus transfer
- Unusual service conditions

This section of the *POWER/VAC Application Guide* provides specific parameters and guidelines for circuit breaker selection and application. Specifically, those circuit parameters and special applications noted in the preceding paragraph are addressed.

CIRCUIT BREAKER RATINGS

POWER/VAC circuit breaker ratings are shown in Table 3-1. Interrupting ratings are for 60-Hz applications. For more complete information concerning service conditions, definitions, and inter-

pretation of ratings, tests, and qualifying terms, refer to the applicable ANSI and NEMA standards listed in Table 1-1.

SELECTION CONSIDERATIONS

Application of the proper circuit breaker requires a definition of its duty requirements, which can then be compared with the choice of a circuit breaker with POWER/VAC ratings and capabilities shown in Table 3-1. It is recommended that ANSI Standard C37.010 (see Ref. 2 of this section) be consulted for guidance in proper determination of duty requirements.

Circuit characteristics which must be considered are discussed in the following paragraphs.

CIRCUIT VOLTAGE

The nominal voltage classes of medium-voltage metalclad switchgear are 4.16 kV, 7.2 kV and 13.8 kV. POWER/VAC switchgear may be applied at operating voltages from 2400 volts through 13,800 volts, providing the nominal and maximum circuit operating voltages do not exceed published POWER/VAC ratings.

TABLE 3-1—POWER/VAC Power Circuit Breaker Characteristics (Symmetrical Rating Basis ANSI C37.06)

Identification			Rated Values								Related Required Capabilities			
ANSI Line Number	Nominal rms Voltage Class (kV)	Nominal 3-phase Class (MVA)	Voltage		Insulation Level		Current		Rated Inter- rupting Time (Cycles)	Rated Per- missible Tripping Delay, Y (Seconds)	Rated Maximum rms Voltage Divided by K (kV)	Current Values		
			Rated Maximum rms Voltage (kV) (1)*	Rated Voltage Range Factor, K (2)	Rated Withstand Test Voltage		Con- tinuous rms Current Rating at 60 Hz (amperes)	Short- circuit rms Current Rating (at Rated Max kV) (kA) (3) (4)				Maximum Symmet- rical Inter- rupting Capability (5)	3 Sec Short- time Current Carrying Capability	Closing and Latching Capability 1.6 K Times Rated Short- circuit rms Current (kA)
(kA)	(kA)													
3*	4.16	250	4.76	1.24	19	60	1200	29	5	2	3.85	36	36	58
4	4.16	250	4.76	1.24	19	60	2000	29	5	2	3.85	36	36	58
5	4.16	350	4.76	1.19	19	60	1200	41	5	2	4.0	49	49	78
5a	4.16	350	4.76	1.19	19	60	2000	41	5	2	4.0	49	49	78
6	4.16	350	4.76	1.19	19	60	3000	41	5	2	4.0	49	49	78
8	7.2	500	8.25	1.25	36	95	1200	33	5	2	6.6	41	41	66
9	7.2	500	8.25	1.25	36	95	2000	33	5	2	6.6	41	41	66
11	13.8	500	15	1.30	36	95	1200	18	5	2	11.5	23	23	37
12	13.8	500	15	1.30	36	95	2000	18	5	2	11.5	23	23	37
13	13.8	750	15	1.30	36	95	1200	28	5	2	11.5	36	36	58
14	13.8	750	15	1.30	36	95	2000	28	5	2	11.5	36	36	58
15	13.8	1000	15	1.30	36	95	1200	37	5	2	11.5	48	48	77
15a	13.8	1000	15	1.30	36	95	2000	37	5	2	11.5	48	48	77
16	13.8	1000	15	1.30	36	95	3000	37	5	2	11.5	48	48	77

High Close and Latch Capability Circuit Breakers (these ratings exceed ANSI-C37.06)

	4.16	250	4.76	1.24	19	60	1200 2000	29	5	2	3.85	36	36	78
	13.8	500	15	1.30	36	95	1200 2000	18	5	2	11.5	23	23	58
	13.8	750	15	1.30	36	95	1200 2000	28	5	2	11.5	36	36	77

*General Electric designation for this circuit breaker is VB-4.16-250

NOTES

1. Maximum voltage for which the breaker is designed and the upper limit for operation.
2. K is the ratio of rated maximum voltage to the lower limit of the range of operating voltage in which the required symmetrical and asymmetrical interrupting capabilities vary in inverse proportion to the operating voltage.
3. To obtain the required symmetrical interrupting capability of a circuit breaker at an operating voltage between 1/K times rated maximum voltage and rated maximum voltage, the following formula shall be used:

$$\text{Required Symmetrical Interrupting Capability} = \frac{\text{Rated Short-circuit Current} \times (\text{Rated Max. Voltage})}{(\text{Operating Voltage})}$$

For operating voltages below 1/K times rated maximum voltage, the required symmetrical interrupting capability of the circuit breaker shall be equal to K times rated short-circuit current.

4. With the limitation stated in 04-4.5 of ANSI C37.04, all values apply for polyphase and line-to-line faults. For single phase-to-ground faults, the specific conditions stated in 04-4.5.2.3 of ANSI C37.04 apply.

5. Current values in this column are not to be exceeded even for operating voltages below 1/K times rated maximum voltage. For voltages between rated maximum voltage and 1/K times rated maximum voltage, follow (3) above.

ANSI-C37.06 symmetrical rating basis is supplementary to ANSI-C37.6 (total current rating basis) and does not replace it. When a changeover from the total current basis of rating to the symmetrical basis of rating is effected the older standards will be withdrawn.

In accordance with ANSI-C37.06, users should confer with the manufacturer on the status of the various circuit breaker ratings.

SYSTEM FREQUENCY

The frequency rating of POWER/VAC metalclad switchgear should coincide with the nominal frequency of the power system. Standard POWER/VAC is available in 60-Hz and 50-Hz ratings, but other frequency ratings are available. Special applications should be referred to the nearest General Electric Sales Office.

SHORT-CIRCUIT CURRENT

Interruption of short-circuit current, quickly and safely, is usually considered the primary function of a circuit breaker. The fault-current interrupting capability of POWER/VAC circuit breakers is stated in three-phase, symmetrical, rms ac amperes. Accordingly, calculation of the maximum available fault duty of a circuit breaker assumes a three-phase bolted fault.

After calculation of short-circuit current duty, choose a POWER/VAC breaker which has a short-circuit current capability that equals or exceeds the expected duty, and, remember to consider the circuit operating voltage when evaluating the circuit breaker's interrupting capability. For example: at 4160 volts, a 4.16 kV — 350 MVA-class circuit breaker with a rated short-circuit current of 41 kA at a maximum rated voltage of 4.76 kV has an interrupting capability of $41 \text{ kA} \times \frac{4.76 \text{ kV}}{4.16 \text{ kV}} = 47 \text{ kA}$ symmetrical rms current.

But at 2.4 kV, the interrupting capability is 49 kA, the maximum symmetrical interrupting capability listed in the rating tables, because 2.4 kV is less than $4.76 \text{ kV}/"k" = 4.76/1.19 = 4.0 \text{ kV}$. (See footnote No. 5, Table 3-1).

CLOSING AND LATCHING CURRENT

Circuit breakers are designed to stay latched, or to close and latch, against a first-cycle maximum

asymmetrical rms current of 1.6 times the maximum symmetrical rms interrupting capability of the circuit breaker. Ordinarily this close and latch capability is satisfactory for most applications. There are some applications, however, in which the calculated² rms value of first-cycle asymmetrical short-circuit current exceeds the closing and latching capability of the circuit breaker. Applications which include a large motor load are a typical example. In these cases, breaker selection may depend on closing and latching capability rather than symmetrical short-circuit capability. The breaker selected might have the next-higher short-circuit current capability or it might have a higher-than-standard closing and latching capability.

CONTINUOUS CURRENT

Feeder and main breaker loading determine required continuous current duty. For continuous loads, select a POWER/VAC breaker with rated continuous current (defined at 60-Hz) equal to or greater than load current.

Note that circuit breakers have no continuous overload rating. When considering circuit breaker application with a generator, a motor, a transformer, or other apparatus having a long-time overload rating, the circuit breaker (and switchgear equipment) must have a continuous-current rating at least equal to the overload rating of the served apparatus. When applied with a forced-cooled transformer, the switchgear continuous-current rating must equal or exceed the transformer forced-cooled current rating.

Circuit breakers may be operated, for short periods, in excess of rated continuous current. This covers such operations as starting motors or energizing cold loads.

SPECIAL SWITCHING APPLICATIONS

Application of power circuit breakers for switching duty may require derating of the circuit breaker or increased maintenance. Particular attention should be given to breakers intended for use in any of the following switching applications:

- Repetitive switching (except arc furnace)
- Automatic reclosing
- Arc furnace switching
- Reactor switching
- Capacitor switching
- Fast bus transfer

For these applications, the usual practice is to first select a circuit breaker based on the criteria provided under "SELECTION CONSIDERATIONS" of this section. Then, consider the switching duty and, if necessary, redetermine the circuit breaker capabilities (continuous-current rating, interrupting rating, etc.), and factor in any modified operating or maintenance requirements. Recheck the circuit breakers' evaluated capabilities against all the basic duty requirements under "SELECTION CONSIDERATIONS."

If the circuit breaker selected initially, and as derated (or otherwise modified), no longer meets the duty requirements of the application, choose the next-higher rated breaker. Repeat the derating or rating adjustment process to confirm that the new breaker has adequate capability.

REPETITIVE SWITCHING (EXCEPT ARC FURNACE)

POWER/VAC circuit breakers can be applied on most power circuits without attention to frequency of operation, since highly repetitive switching duty is uncommon. Typical switching duties include motor starting, switching of distribution circuits, transformer magnetizing current, and other miscellaneous load-current switching. While magnitude of current switched in these applications can vary from very light load to the maximum permissible for a particular circuit breaker, switching is generally infrequent; thus, no derating is required.

Standard POWER/VAC circuit breakers may be operated as often as 20 times in 10 minutes or 30 times in one hour without derating for switching duty. Further frequency of operation capabilities are given in Table 3-2. When operated under usual

service conditions and for other than arc furnace switching, standard POWER/VAC circuit breakers are capable of operating the number of times shown in the table. Operating conditions, servicing requirements and permissible effects on the breakers are specified in the notes under the table.

AUTOMATIC RECLOSING

When POWER/VAC circuit breakers are used for automatic reclosing duty to maintain service continuity, they must be derated in accordance with standard capability factors¹. These apply to all high-voltage circuit breakers rated up to 72.5 kV and with continuous-current ratings of no more than 1200 amperes.

Breakers having continuous-current ratings above 1200 amperes are not intended for reclosing service applications. When such applications arise, refer them to the nearest General Electric Sales Office.

Capability factors for POWER/VAC circuit breakers used in automatic reclosing duty applications are shown in Figures 3-1 and 3-2. To ensure proper determination of POWER/VAC circuit breaker capabilities in reclosing applications, use this step-by-step calculating procedure.

Calculation of Reclosing Capabilities

- A duty cycle shall not contain more than five opening operations.
- All operations within a 15-minute period are considered part of the same duty cycle.
- The circuit breaker may be applied, at the determined operating voltage and duty cycle, to a circuit for which the calculated short-circuit current does not exceed the symmetrical interrupting capability, as determined by the following procedure.
- If the X/R ratio for the circuit exceeds 15, refer to ANSI-C37.010 for guidance.

Procedure

- Step 1 — Determine the breaker symmetrical interrupting capability at the operating voltage from Table 3-1 (Note 3).

TABLE 3-2—Repetitive Duty and Normal Maintenance for POWER/VAC Circuit Breakers Used for Other than Arc Furnace Switching

Breaker		Maximum No. of Operations Between Servicing (Note A)	Number of Operations				
Type	Continuous Rating (Amperes)		No-load Mechanical (Notes B, E, F, G, H, I)	Full-load Non-fault (Notes C, E, F, G, H, J)	Full-load Fault (Notes D, E, F, G, H, I, K)	Inrush Non-fault (Notes D, E, F, G, H, J)	Inrush Fault (Notes D, E, F, G, H, I, K)
Column 1		Column 2	Column 3	Column 4	Column 5	Column 6	Column 7
VB-4.16-250 VB-4.16-250	1200 2000	2000	10000	5000 3000	1000	3000 2000	750
VB-4.16-350 VB-4.16-350 VB-4.16-350	1200 2000 3000	1000	5000	2500	500	1500	400
VB-7.2-500 VB-7.2-500 VB-13.8-500 VB-13.8-500 VB-13.8-750 VB-13.8-750	1200 2000 1200 2000 1200 2000	2000	10000	5000 3000 5000 3000 5000 3000	1000	3000 2000 3000 2000 3000 2000	750
VB-13.8-1000 VB-13.8-1000 VB-13.8-1000	1200 2000 3000	1000	5000	2500	500	1500	400

*Table 2 is based on requirements of NEMA Standard SG4.

Servicing

A. Servicing shall consist of adjusting, cleaning, lubricating, tightening, etc., as recommended by the Company. The operations listed are on the basis of servicing at intervals of six months or less.

Circuit Conditions

B. When closing and opening no load.

C. When closing and opening currents up to the continuous current rating of the breaker at voltages up to the maximum design voltage and at 80 per cent power factor or higher.

D. When closing currents up to 600 per cent and opening currents up to 100 per cent (80 per cent power factor or higher) of the continuous current rating of the breaker at voltages up to the maximum design voltage.

Operating Conditions

E. With up to rated control voltage applied.

F. Frequency of operation not to exceed 20 in 10 minutes or 30 in 1 hour. Rectifiers or other auxiliary devices may further limit the frequency of operations.

G. Servicing at not greater intervals than shown in Column 2.

Conditions of the Breaker After the Operations Shown in the Table

H. No parts shall have been replaced.

I. The breaker shall meet all of its current, voltage, and interrupting ratings.

J. The breaker shall meet all of its current and voltage ratings but not necessarily its interrupting ratings.

Operation Under Fault Conditions

K. If a fault operation occurs before the completion of the permissible operations, it is not to be inferred that the breaker can meet its interrupting rating or complete its number of operations without servicing and making replacements if necessary.

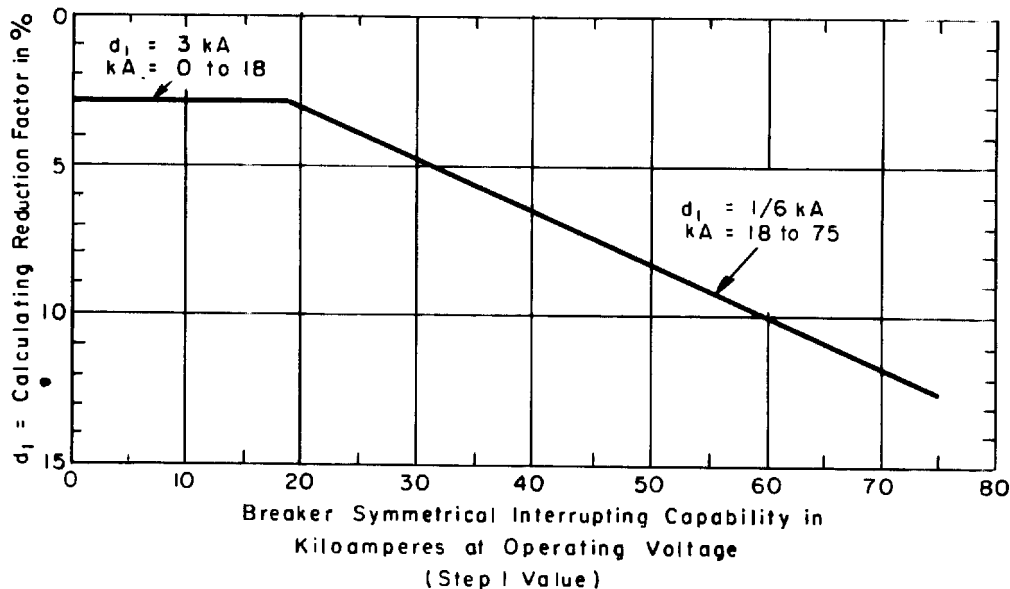


Figure 3-1. Reclosing capability curve for determining d_1 .

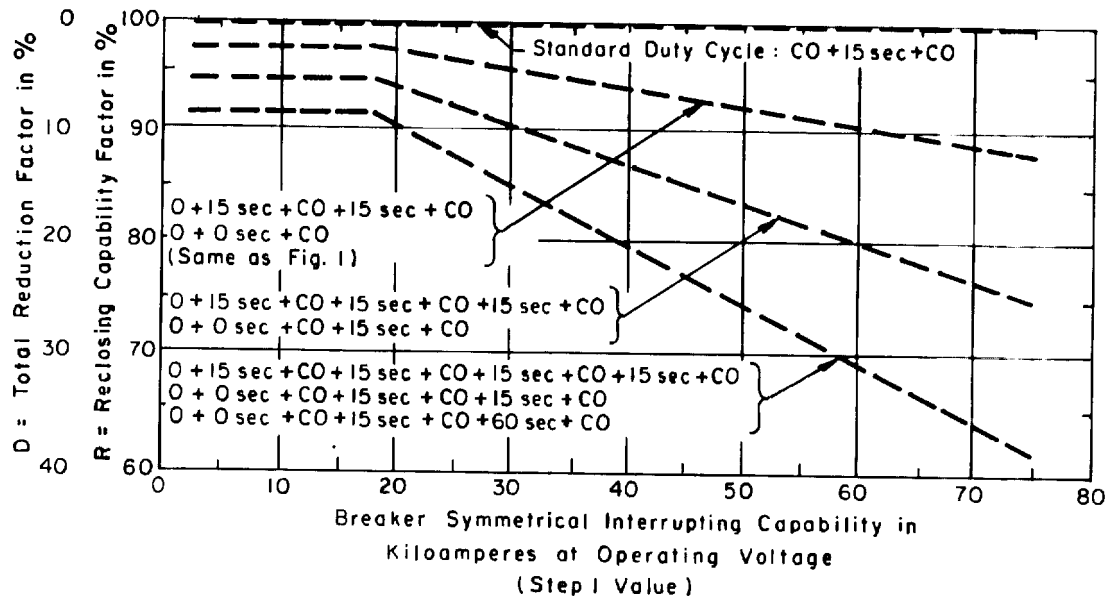


Figure 3-2. Reclosing capability factor curves for typical duty cycles.

Step 2 — Determine the factor d_1 from the reclosing capability curve in Figure 3-1 for the current value determined in Step 1.

Step 3 — Determine the factor D from the following equation:

$$D = d_1 (n-2) + d_1 \frac{(15-t_1)}{15} + d_1 \frac{(15-t_2)}{15} + \dots + d_1 \frac{(15-t_n)}{15}$$

where:

D = total reduction factor (in percent).

d_1 = calculating factor for D in percent of breaker symmetrical interrupting capability at operating voltage.

n = total number of openings in duty cycle.

t_1 = duration (in seconds) of first time interval between CO operations that is less than 15 seconds.

t_2 = duration (in seconds) of second time interval between CO operations that is less than 15 seconds.

t_n = duration of n^{th} time interval. . .

Step 4 — Calculate the reclosing capability factor (R) in percent where:

$$R = 100 \text{ minus } D$$

For some typical duty cycles, R can be determined directly from the appropriate curves in Figure 3-2.

Step 5 — The revised symmetrical interrupting capability of the circuit breaker for the operating voltage and duty cycle desired is now determined by multiplying the Step 1 symmetrical interrupting capability by R , as determined in Step 4.

ARC FURNACE SWITCHING

Arc furnace switching duty is more repetitive than normal switching duty. The circuit breaker is applied on the primary side of a relatively high-impedance transformer and the usual duty is frequent switching (50 to 100 times per day) of the transformer magnetizing current. Switching is required when the transformer is de-energized for tap changing, when taking melt samples, or when adding alloys. In addition to this switching duty, transformer through-faults must occasionally be interrupted.

Circuit Breaker Selection

This heavy-duty application requires circuit breaker capabilities and maintenance schedules different from those required for other switching duty.

POWER/VAC circuit breakers designed for arc furnace switching are capable of operating the number of times given in Table 3-3, providing they are operated under usual service conditions. Operating conditions, servicing requirements, and permissible effects on the breakers are given in the notes following the table.

TABLE 3-3 —Repetitive Duty and Maintenance Requirements for POWER/VAC Circuit Breakers Applied for Arc Furnace Switching.

Breaker		Arc-Furnace Full Load Rating (Amperes)	Maximum Number of Operations Between Servicing (Note A)	Number of Operations	
Type	Continuous Current Rating (Amperes)			No Load Mechanical (Notes B, C, D, E, F, and G)	Switching and Interrupting (Notes C, D, E, F, H, and I)
Column 1	Column 2	Column 3	Column 4	Column 5	Column 6
VB-4.16-250 VB-13.8-500 VB-7.2-500 VB-13.8-750	1200	Up to 1200	2000	10000	See Schedule 1
VB-7.2-500 VB-13.8-500 VB-13.8-750	2000	1201 to 2000	2000	10000	See Schedule 2
VB-4.16-350 VB-13.8-1000	1200	Up to 1200	1000	5000	See Schedule 1
VB-4.16-350 VB-13.8-1000	2000	1201 to 2000			See Schedule 2
VB-4.16-350 VB-13.8-1000	3000	1201 to 3000			

Servicing

A. Servicing shall consist of adjusting, cleaning, lubricating, tightening, etc., as recommended by the Company. The operations listed are on the basis of servicing at intervals of six months or less.

Circuit Conditions

B. When closing and opening no load.

Operating Conditions

C. With rated control voltage maintained at 90 to 100 per cent of rated value.

D. Frequency of operation not to exceed 20 in 10 minutes or 30 in 1 hour.

E. Servicing at no greater intervals than shown in Column 4.

Condition of the Breaker After the Operations Shown in the Table

F. No parts shall have been replaced.

G. The breaker shall meet all of its current, voltage, and interrupting ratings.

Operation Under Fault Conditions

H. If four operations interrupting fault currents in excess of 6000 amperes occur before completion of the permissible number of operations indicated, interrupter should be checked for contact wear.

I. Interrupting currents of 6000 amperes and below. Interrupter should be checked for contact wear upon completion of the specified number of operations.

SCHEDULE 1

2500 operations interrupting no load or load currents less than 1200 amperes, plus 200 operations interrupting fault currents up to 3600 amperes, plus one opening operation (O) at rated interrupting current.

SCHEDULE 2

2000 operations interrupting no load or load currents less than 2000 amperes continuous current rating in column 2, plus 200 operations interrupting fault currents up to 6000 amperes, plus one opening operation (O) at rated interrupting current.

REACTOR SWITCHING

Standard POWER/VAC circuit breakers are capable of switching reactive load current up to the full continuous current rating of the breaker.

CAPACITOR SWITCHING

Capacitor banks are generally applied on both utility and industrial power systems to improve voltage regulation and system stability. POWER/VAC circuit breakers are applicable to shunt-capacitor-bank switching in accordance with the capabilities listed in Table 3-4. Note that the capacitor switching capability of POWER/VAC vacuum circuit breakers is independent of the continuous-current rating of the breaker.

Shunt-bank capacitor switching means one breaker feeding one 3-phase capacitor bank. If this circuit is closely paralleled by another switched capacitor bank, Table 3-4 will not apply. These situations require evaluation of such factors as local high-frequency equalizing currents flowing between the separated, switched capacitor banks. Complex applications, including back-to-back switching, should be referred for review to the nearest General Electric Sales Office.

TABLE 3-4—POWER/VAC Circuit Breaker Capacitor Switching Capability

Capacitor Voltage	Capability for 1200A, 2000A, and 3000A continuous current rated POWER/VAC circuit breakers	
	Capacitor Switching Capability (Amperes)	Equivalent Capacitor Bank Rating (kvar*)
2400	630	1940
4160	630	3360
4800	630	3880
7200	630	5820
12470	630	10075
13800	630	11150

*Maximum three-phase, single capacitor bank, nameplate kvar, including required multiplying factor of 1.35.

Footnotes: The capacitor-bank rating is subject to the following conditions:

1. The transient voltage from line to ground shall not exceed 2½ times maximum design line-to-ground crest voltage measured at the breaker terminals.
2. The number of restrikes or reignitions shall not be limited as long as the transient voltage to ground does not exceed the value given in Footnote 1.
3. The capacitor bank rating applies only to single bank switching as noted herein.
4. Interrupting time is in accordance with the rated interrupting time of the circuit breaker.

FAST BUS TRANSFER

Fast bus transfer is normally used for transferring a generating station auxiliary bus to an emergency power source upon failure of the normal source of power. During this transfer it is essential that bus "dead time" be as short as possible to prevent loss of critical auxiliary functions. "Fast" transfer means there is no intentional time delay in the transfer of a bus or load from one source of power to another. POWER/VAC circuit breakers with stored-energy closing meet the critical requirements for fast transfer.

Two sequences of circuit breaker operation can be used to achieve fast transfer. In the first sequence, the TRIP signal to the opening breaker and the CLOSE signal to the closing breaker are given simultaneously. Care should be taken to prevent the possibility of overlap, or momentary paralleling of sources. Overlap means that the second source could be closing into a fault or that the equipment could be tied to the high-voltage system through the auxiliary system while the two sources are momentarily paralleled. To ensure against overlap, several cycles of time delay should be provided, using a timing relay.

In the other operation sequence, a TRIP signal is first given to the tripping breaker. Then a "b" contact (open when the breaker contacts are closed) on the tripping breaker initiates the closing of the second breaker. The amount of dead time depends on whether a standard auxiliary switch "b" contact or a special early "b" (faster) contact is used.

Typical dead-times for various types of high-speed transfer conditions using POWER/VAC circuit breakers are shown in Table 3-5.

TABLE 3-5—Typical Dead-Times for Fast Transfer Using POWER/VAC Circuit Breakers

Breaker		Tolerance (Plus & Minus) (Cycles) (2)	Nominal Dead Time for Fast Transfer (Cycles) (1)					
			Simultaneous Close & Trip		Trip Then Close Using Early "b" Contact (3)		Trip Then Close Using Std. "b" Contact (4)	
Type	Cont. Current Rating, (Amperes)							
			No Arcing (6)	With Arcing (7)	No Arcing (6)	With Arcing (7)	No Arcing (6)	With Arcing (7)
VB-4.16-250	1200 2000	1.0	2.1	0.8	4.5	3.2	5.9	4.6
VB-4.16-350	1200	1.5	1.4	Note (5)	3.7	1.8	5.1	3.2
	2000	1.5	1.5		3.8	2.2	5.2	3.6
	3000	1.3	1.5		3.8	2.2	5.2	3.6
VB-7.2-500	1200 2000	1.0	2.1 2.3	0.8 1.0	4.4 4.7	3.1 3.3	5.8 6.1	4.5 4.7
VB-13.8-500	1200 2000	1.0	2.4 2.6	1.0 1.2	4.8 4.9	3.4 3.5	6.2 6.3	4.8 4.9
VB-13.8-750	1200 2000	1.2	2.2	0.6	4.5	2.9	5.9	4.3
VB-13.8-1000	1200	1.7	1.8	Note (5)	4.1	2.1	5.5	3.5
	2000	1.7	2.4		4.7	3.0	6.1	4.4
	3000	1.4	2.4		4.7	3.0	6.1	4.4

Footnotes:

- (1) Control Voltage at rated Value for 125 V-dc, 250 V-dc or 230 V-ac (60 Hz).
- (2) Variance covers entire current range from lowest values to maximum rating interrupting current.
- (3) Early "b" contact operates at time arcing contacts separate.
- (4) Standard "b" contact located on Breaker Auxiliary Switch. Time from arcing contact parting to "b" contact making is approximately 1.4 cycles.
- (5) Nominal times produce overlap.
- (6) Contact separation to contact making.
- (7) End of arcing to contact making.

SERVICE CONDITIONS

POWER/VAC metalclad switchgear ratings and capabilities are based on operation under certain defined service conditions, defined as "usual". Conditions other than usual are called "unusual". Factors used to classify service conditions are altitude, ambient temperature, and a variety of others, such as the presence of atmospheric contaminants, unusual storage conditions, and requirements for tamper-resistance. These factors are specified for circuit breakers in ANSI-C37.04-1964

(Circuit Breaker Rating Structure) and for equipment in ANSI-C37.20-1969 (Switchgear Assemblies), and are summarized here for application guidance.

Application of POWER/VAC circuit breakers under conditions other than "usual" may require significant derating, special construction or use of special protective features.

Circuit Breaker Selection

USUAL SERVICE CONDITIONS

POWER/VAC circuit breakers (and switchgear assemblies) are suitable for operation at their standard nameplate ratings:

- Where ambient temperature is not above 40 C or below -30 C (104 F and -22 F)
- Where the altitude is not above 3300 feet (1000 meters).

NOTE: For switchgear assemblies (breakers and housings combined) there is one additional stipulation:

- Where the effect of solar radiation is not significant. (See Ref. 5 of this section.)

UNUSUAL SERVICE CONDITIONS

Abnormal Temperature

The planned use of POWER/VAC circuit breakers or switchgear assemblies at other than normal ambient temperatures (+40 C to -30C) shall be considered as special. Such applications should be referred to the nearest General Electric Sales Office for evaluation.

High Altitude

POWER/VAC circuit breakers and switchgear assemblies utilize air for an insulating and cooling medium. Operation at altitudes above 1000 meters will result in a higher temperature rise and lower dielectric strength because the air is thinner. Thus, certain circuit breaker and switchgear capabilities must be corrected to adjust for high-altitude operation.

For operation of POWER/VAC circuit breakers and switchgear at altitudes above 1000 meters the basic impulse insulation level (BIL), the rated maximum voltage, and the rated continuous current shall each be multiplied by the appropriate correction factors shown in Table 3-6. For proper application, the derated values should equal or exceed the duty requirements of the application.

TABLE 3-6—Altitude Correction Factors for POWER/VAC Circuit Breakers and Switchgear

Altitude (feet)	Rating Correction Factor*	
	Rated Continuous Current	Rated Maximum Voltage and Insulation Level
3,300 (and below)	1.00	1.00
5,000	0.99	0.95
10,000	0.96	0.80

Footnote:

*Values for intermediate altitudes may be determined by linear interpolation.

Other Unusual Conditions

Besides abnormal temperature and high altitude there are other unusual service conditions which may require special protecting features or affect construction. Some of these are:

- Exposure to corrosive vapors, explosive fumes, excessive dust or dirt, salt spray, steam, dripping water, and other similar conditions.
- Exposure to abnormal vibration, shock, unusual transportation, or special storage conditions.
- Installations accessible to the general public.

BREAKER MOUNTED ACCESSORIES

POWER/VAC circuit breakers can be furnished with a redundant tripping circuit, including the additional shunt trip coil. It is designed specifically for use on breakers applied in nuclear power-station switchgear applications. This feature is rarely used in normal applications since the standard trip circuit is extremely reliable.

A four-stage auxiliary switch is furnished on every POWER/VAC circuit breaker. Three contacts are used for the close-and-trip circuits, leaving two "a" and three "b" contacts for Purchaser use. Additional switch stages are not available on the breaker. They must be provided using an auxiliary switch stationary-mounted on the equipment.

REFERENCES

1. ANSI Standard C37.06-1971, Schedules of Preferred Ratings and Related Required Capabilities for AC High Voltage Circuit Breakers Rated on a Symmetrical Current Basis.
2. ANSI Standard C37.010-1972, Application Guide for AC High Voltage Circuit Breakers.
3. ANSI Standard C37.04-1964 (R1969), Circuit Breaker Rating Structure.
4. ANSI Standard C37.20-1969, Switchgear Assemblies.
5. ANSI Standard C37.24-1971, Guide for Evaluating the Effect of Solar Radiation on Outdoor Metalclad Switchgear.

Section 4

Control Power Equipment

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Control Power Equipment

INTRODUCTION

This section of the Application Guide addresses specific control power requirements and provides

guidance in selecting the proper type of control power equipment.

CONTROL POWER REQUIREMENTS

Equipment necessary to provide control power for POWER/VAC switchgear must have sufficient capacity to deliver the maximum power required, at the proper voltage, under any operating condition.

The most important consideration in selecting a control power source is that it must provide tripping power for the circuit breakers during protective relay operation. Also, it should be capable of closing the breakers without direct manual operation. Other requirements can include:

DC	AC
Indicating lamps	Indicating lamps
Emergency lights	Equipment heaters
Emergency motors	Equipment lights and convenience outlets
Excitation power (brushless motors, etc.)	Excitation power (brushless motors, etc.)
	Equipment ventilating fans
	Remote lights (on structures, etc.)

All of these requirements must be considered in determining the type and rating of the control power source.

Sources of control power for POWER/VAC metalclad switchgear are storage batteries (with charger) for dc control, and transformers for ac control. When ac is used for closing, the tripping power must be obtained from capacitors fed from rectified ac, or from a "tripping only" battery. The choice between these alternatives depends on factors such as the size of the switchgear installa-

tion, the need to operate breakers simultaneously, the degree of reliability required, expansion plans, the expected environmental conditions, maintenance support availability, and the economics related to these considerations.

CLOSING AND TRIPPING

Successful operation of POWER/VAC metalclad switchgear depends on a reliable source of control power which will, at all times, maintain a voltage at the terminals of electrically operated devices within the rated operating voltage range. In general, the operating voltage range of a switchgear equipment is determined by the rated operating voltage range of the circuit breaker. These ranges, as established by NEMA standards, are given in Table 4-1.

Operating currents for POWER/VAC circuit breakers are given in Table 4-2.

Table 4-1
Standard Control Voltage and Operating Ranges
For POWER/VAC Circuit Breakers

Nominal Control Voltage	Operating Range (Volts)	
Volts	Stored-energy Mechanism	
	Spring Motor and Closing Spring Release Coil	Tripping Coil
48	36-52	28-60
DC 125	90-130	70-140
250	180-260	140-280
AC 115	95-125	not available in POWER/VAC
230	190-250	

Table 4-2
Operating Currents of
POWER/VAC Circuit Breakers

Type of Breaker	Closing Current (Amperes)										Tripping Current* (Amperes)		
	At 48 Volts DC		At 125 Volts DC		At 250 Volts DC		At 115 Volts AC		At 230 Volts AC		At 48 Volts DC	At 125 Volts DC	At 250 Volts DC
	Closing Spring Release Coil	Spring Motor	Closing Spring Release Coil	Spring Motor	Closing Spring Release Coil	Spring Motor	Closing Spring Release Coil	Spring Motor	Closing Spring Release Coil	Spring Motor			
VB-4.16-250													
VB-4.16-350													
VB-7.2-500	8	16	6	8	3	5	8	8	4	5	6	3	3
VB-13.8-500													
VB-13.8-750													
VB-13.8-1000													

*Fuses for the tripping circuit should have an ampere rating of at least 2 times the tripping current and not less than 35 amperes.

Breaker Tripping

POWER/VAC circuit breakers are provided with means for manual tripping (push button) and for electrically actuated tripping (trip coil). Electrically actuated tripping devices are used for two functions:

- As a means of opening the breaker in the process of normal switching operations initiated by an operator, or
- As a means of automatically opening the breaker for circuit protective purposes, under abnormal conditions.

Electrical tripping is accomplished when external power, from a battery or from a rectified ac source (with capacitor), is directed into the breaker trip coil. Normal switching tripping uses an operator control switch. Automatic tripping occurs when a contact on a protective relay closes, actuated by power circuit instrument transformers.

When deciding between dc battery trip and ac capacitor trip, the following points must be considered:

- For a single breaker, or a few breakers, the capacitor trip device has lower cost than a battery, but a trip device is required for each breaker.
- A battery source is more reliable, but requires more maintenance than a capacitor trip device.

- If a battery is used for tripping, dc closing power can also be obtained for little additional cost.

DC BATTERY TRIP — When properly maintained, a battery offers the most reliable tripping source. It requires no auxiliary tripping devices, and uses single-contact relays which directly energize a single trip coil in the breaker. Power circuit voltage and current conditions during time of faults do not affect a battery-trip supply; therefore, it is considered the best source for circuit breaker tripping. Additional advantages are that, usually, only one battery is required for each location, and it may be used to operate other equipment such as high-voltage circuit breakers or protective grounding switches.

Once a battery has been selected for tripping purposes, it can, after proper evaluation of additional loads, also be used for breaker closing power. For indoor applications, if the battery can be located close to the switchgear, a 48-volt battery operating level is usually suitable. For more general use, a 125-volt battery is recommended, but 250-volt batteries can be used if other conditions require that voltage. In outdoor locations, space considerations in the switchgear usually restrict the battery to a 48-volt rating.

Long service can be obtained from batteries when they receive proper maintenance, are kept fully charged, and when the electrolyte is maintained at the proper level. For equipment in

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outlying locations where periodic battery maintenance would be difficult, the capacitor trip device may offer overall advantages.

CAPACITOR TRIP — Capacitor trip devices are available in two types: the "simple" type and the "auto-charge" type. The "simple" capacitor trip device consists of a capacitor and a half-wave rectifier, charged from an ac potential source, such as a control power transformer. This unit retains adequate charge for a short time (about 30 seconds) after ac is lost.

The "auto-charge" trip device consists of the "simple" device, plus a voltage amplifier, a battery, and a battery charger. Under normal conditions, with 230-volt ac power used for breaker closing, the single-cell, sealed, rechargeable, nickel-cadmium battery is maintained at full charge by the small charger connected to the 230-volt ac source. Upon loss of ac power, the voltage amplifier steps up the low battery voltage to the higher voltage needed to maintain charge on the capacitor for several days.

The "auto-charge" capacitor trip device is provided on POWER/VAC switchgear whenever ac trip or capacitor trip is specified.

Breaker Closing

Closing power availability should be independent of voltage conditions on the power system associated with the switchgear. Accordingly, a 125-volt or 250-volt dc battery is normally considered to be the most reliable auxiliary power source. Nevertheless, in many instances, the storage battery or other independent power source necessary to achieve this goal may require an investment which is considered too high for the advantages gained. This is particularly true for small lineups, consisting of only a few circuit breaker units.

Generally, the choice between dc closing power derived from a battery and ac closing power derived from a control power transformer is an economic one, dictated by desired system reliability. There are other factors, however, which also influence this choice. These are:

- Need to close breakers with the power system de-energized.
- Availability of housing space for a battery and its associated charging equipment.

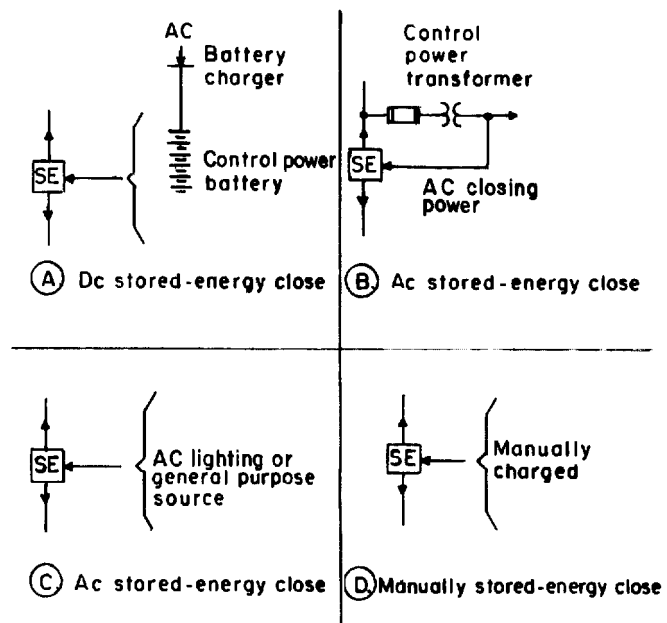


Figure 4-1. Closing mechanism arrangements.

- Estimated lowest ambient temperature and its effect on battery capability.
- Maintenance requirements for a battery and battery charger.
- Expected future equipment additions which may affect the present choice of closing-power source.

The POWER/VAC stored-energy operating mechanism can use the closing arrangements shown in Figures 4-1A through 4-1D.

When the mechanism is operated from alternating current, the current required is such that it can be taken from a control power transformer or a general-purpose or lighting source, as shown by Figures 4-1B and 4-1C. The energy for the next operation is stored in the springs as soon as the breaker is closed. To permit control switch or automatic initiation of closing, the ac source must also be present at the time of breaker closing to energize the spring-release solenoid; however, at attended locations, a somewhat less reliable ac control source may be permissible where an operator can manually release the closing springs if necessary. The POWER/VAC breaker mechanism is also suitable for manual operation (Figure 4-1D),

both for charging the springs and for releasing them to close the breaker.

For any control power source used for breaker closing, the maximum closing load should be calculated using Table 4-2 values. Usually, only one breaker will be closed at a time, but the possibility of simultaneous closing of two or more breakers must be examined. This possibility will depend on the type of application and any special control requirements, such as load restoration. Simultaneous closing of two breakers could occur with multiple-breaker, motor-starting equipment, or with automatic reclosing breakers. Also, on large installations, with several different control points, different operators could cause simultaneous manual operations.

INDICATING LAMPS

Position indicating lamps for each circuit breaker are operated from the trip fuses with dc closing power, or the closing fuses on either ac control or a "tripping only" battery. These lamps are a small — but steady — load, which is of concern particularly in dc applications. The total load is the sum of:

- One indicating lamp per breaker.
- Lamps used to supervise fuses of lockout relays, etc.
- Additional lamps — if any — used for remote indication in parallel with switchgear lamps.

Burden is usually 0.035 amperes per lamp, regardless of voltage, and is assumed to be carried (by the battery) for not more than eight hours.

EQUIPMENT HEATERS

To minimize the occurrence of moisture condensation, all outdoor POWER/VAC switchgear units are supplied with Calrod® space heaters, which are to be energized at all times. A 75-Watt heating element is located in each breaker or auxiliary compartment, as well as in each cable area.

Heaters are rated 115 volts ac, for operation from a 115-volt two-wire, or 115/230-volt three-wire source. Heater load is 300 Watts per vertical section.

COMFORT HEATING

Comfort heaters for use in outdoor aisle-type POWER/VAC installations must be supplied by the Purchaser. A grounding-type receptacle, rated 250 volt ac, 20 amperes, is provided at each end of the aisle for portable comfort heaters.

When sizing the ac control power source, allow for 5000 VA ac load at 230 volts for each heater receptacle intended for use.

RELAYING

With dc control power, allowance must be made for simultaneous tripping of two or more breakers. Requirements for simultaneous tripping depend, first, on the number of breakers on the dc source, and, second, on the kind of relaying. Based on probability considerations, a guide to the possible number of simultaneous trippings is given in Table 4-3.

Table 4-3
Simultaneous Breaker Tripping

Number of Breakers in lineup	1	2	3-5	6-10	Above 10
Breakers Tripped By:	Probable Maximum Number of Breakers Tripping Simultaneously				
Time delay fault protection	1	1	2	3	(a)
Instantaneous fault protection	1	2	3	4	(a)
Undervoltage or bus differential (b)	1	2	All	All	All

(a) Depends upon operating conditions.

(b) Use of single undervoltage or bus differential relay for tripping all breakers.

Lockout relays, when present, as in differential relay circuits, require special treatment:

- With ac operation, a capacitor trip device must be included for operation of each lockout relay.
- With dc operation, the relay coil current must be added to the simultaneous breaker demand, since the relay does not cut itself off until after the breaker coils have been energized. A guide to this current is:

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Operating voltage (volts)	48 V	125 V	250 V
HEA relay coil current (amperes)	10.7 A	5.5 A	2.4 A

FANS

Outdoor aisle-type POWER/VAC switchgear is available with roof fans for aisle ventilation. The standard fan uses a 1/2 hp single-phase motor, for operation from 120-volts ac only; provide 950 VA per fan.

Substation transformers associated with switchgear sometimes include fans. When energized from the switchgear control power source, the fan load must be included in the total burden on the source. Usually this is a 230-volt, single-phase load; from one to several kVA per transformer.

LIGHTS

Outdoor POWER/VAC switchgear, both aisle and non-aisle types, is provided with receptacles for 120-volt incandescent lamps. The control power allowance for these should be 100 Watts per vertical section.

Other lighting loads, such as outside floodlights, must be factored into the ac control power load based on actual requirements.

CONVENIENCE OUTLETS

In outdoor POWER/VAC switchgear, 115-volt duplex grounding convenience outlets are provided. With aisle-less design, one outlet is provided per vertical section. With aisle-type construction, one outlet is located at each end of the aisle.

Control power allowance should be a nominal 500 Watts for each duplex outlet.

EXCITATION POWER

When synchronous motors with brushless field excitation are controlled directly from the switchgear, power for the exciter field source is frequently required from the switchgear control

power source. This excitation demand varies with the machine, from 1 to perhaps 8 amperes dc, usually at approximately 100 volts. With rectified ac supply to the field, the ac equivalent of the dc field current must be included in the total CPT loading. (As a first approximation, multiply the dc amperes by 1.15 and convert to VA by multiplying this product by 125 volts.) When the exciter field is fed directly from the battery, the field demand — as a nominal 8-hour load — must be included in the dc steady load total.

Generators with static regulators usually require a separate transformer on the incoming leads of the generator breaker. This transformer is of the same epoxy-cast coil, dry type, as the switchgear CPT, but is located in its own rollout tray. Such dedicated transformers are not part of the regular control power loading.

BREAKER REMOTE RACKING

When the usual manual racking means is supplemented by a motor, the load on the control power source is the same as for the breaker spring-charging motor; see Table 4-2.

OTHER LOADS

With dc control, when the charger is supplied from the switchgear ac control power transformer, the charger load must be included in the total ac demand. Using charger dc ampere rating as a base, some ratios of equivalent ac load at different supply and battery voltages are tabulated in Table 4-4.

For example, a 6-ampere charger, fed at 115 volts, and supplying a 125-volt battery, has an ac load of approximately 13.8 amperes (6 A x 230%) at full output, or 1590 VA (13.8 A x 115 V). While this would be an intermittent condition, with the normal load being about 0.5 to 1.0 amperes dc, the

Table 4-4

AC Supply Voltage	Ac load factor for charger Battery Voltage	
	48 V	125 V
115 V	75%	230%
230 V	38%	115%

ac control source must be sized to handle the 13.8 ampere load.

With automatic control schemes, some relays will be energized continuously after the first breaker is closed. The amperes drawn by these relays must be totalled and included with the indicating lamp load, etc., to arrive at the total steady load.

Emergency loads on switchgear batteries, such as room lights or dc pump motors, usually result in a much larger battery than required for the switchgear alone. Lights are usually assumed to be used for three hours, and then extinguished. Motor load duration must be specified by the user.

CONTROL POWER SOURCE SELECTION

For a particular station, selection of a control power source may require sizing of a battery, a control power transformer, or — sometimes — both. The first step is to establish the size of each load of the various kinds enumerated. Second, for batteries the short-time loads, such as breaker tripping, and the steady loads, such as lamps, must be converted to a common rate base.

With the relatively small demands placed on the control power source by individual breakers, as detailed in Table 4-2, other loads must be evaluated carefully, since they may represent the major demand. Particularly with batteries, long-time loads must have a time period stated, since a battery, with the charger "off", is not a "continuous" source.

DC CONTROL POWER EQUIPMENT

A dc control power source consists of a storage battery and an associated charger. The battery is connected to the dc control power bus and the charger at all times. Large momentary loads are supplied from the battery, but it otherwise does very little work in normal operating situations.

Two types of batteries are used with switchgear: lead-acid or nickel-cadmium. Several classes of each type are produced, each with different costs and with different ratios between short-time and long-time capacities. The exact type and class must be established before performing the conversion of loads to a common rate base.

Lead-acid Batteries

Listed, in order of increasing cost, are several classes of lead-acid batteries.

- Pasted plate, with lead-antimony grids.
- Lead-calcium; a pasted-plate construction with calcium replacing antimony as the additive for grid strength.
- Tubular positive (also trade-named "Iron-clad"); a design particularly suitable where considerable long-time load is applied on a "cycle" basis. Available only in relatively large (for switchgear) sizes.
- Planté; where the positive plate active material is formed from pure lead (also trade-named "Manhex").

Pasted plate, lead antimony, is the basic lead-acid battery, familiar in another form as the automobile battery. For control work (compared to auto batteries), thicker plates and lower gravity of acid provide longer life and allow long-time trickle or "float" charging. With different plate thicknesses, expected life is from 6 to 14 years.

Lead-calcium construction has longer expected life (up to 25 years) than lead-antimony — at a rather small increase in cost. The "pure lead" electrochemical characteristics, compared to the other classes, require slightly different (higher) charging voltages.

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The tubular-positive class evolved from electric battery truck service; hence, it is most suitable for large stations with considerable emergency lighting and/or motor loads, etc.

Planté batteries are long-life cells, with 20 to 25 years of expected life. Increased manufacturing time for the pure-lead positive plates, compared to pasted plates, leads to higher prices. Electrically, short-time rates are somewhat higher, and ampere-hours slightly less, for a given cell size, than in pasted-plate construction.

Nickel-cadmium Batteries

Nickel-cadmium batteries are more expensive than lead-acid, in general, but have some advantages. Maintenance is less, life is somewhat longer, low-temperature discharge currents are higher for a given size, and they can be charged more rapidly.

Pocket-plate cells are the normal construction used with switchgear; they are made in three different plate thicknesses. The thickest plates are not suitable for short-time applications. Medium or thin-plate cells are used with switchgear; the choice depending upon the relative amounts, respectively, or long- or short-time load.

Sintered-plate construction, which is relatively new, is used mostly in "cordless" appliances, seldom in switchgear.

Battery Capacity and Sizing

The capacity of a storage battery is usually expressed in ampere-hours, or the product of amperes output multiplied by hours of discharge, with the basic rate being for eight hours. Battery capacity, however, may be expressed at many time rates other than the eight-hour rate. For switchgear short-time loads, such as breaker tripping, the one-minute rate per cell — discharging to 1.75 volts for lead-acid, or 1.14 volts for nickel-cadmium — is used. The one-minute rate does not exhaust the battery completely; rather, it is the rate which causes the terminal voltage to drop to the stated value early in the discharge period. Further, published data is for cells at 25 C (77 F), and battery rating values must be reduced when the battery is

at a lower temperature. The one-minute rating at -10C (15 F), for instance, is half the 25 C rating.

The *common rate base* mentioned earlier, refers to the conversion of one-minute-rate loads, etc. to equivalent ampere-hours at the eight-hour rate, and also includes any compensation for operating temperature. This conversion can be done in one of the following ways, after collection of the detailed load data.

- Direct use of specification sheets, etc. from battery makers.
- Referral of data to switchgear manufacturers.
- Referral of data to battery manufacturers.

For direct calculation, the battery is assumed to have carried its steady loads for eight hours, and then — as the worst case — subjected to the maximum load involving the one-minute rate. Indoor locations assume that the battery is at 25 C (77 F); outdoor locations at -10 C (15 F). A minimum size limit of cell is suggested to allow for unknowns: 20 ampere-hours for lead-acid, or 15 ampere hours for nickel-cadmium.

A small station, for example, with the battery located indoors, might have three breakers, with closing and tripping duty, and no steady load except the switchgear indicating lamps. Two of the breakers have instantaneous attachments on their overcurrent relays, so that — per Table 4-3 — simultaneous tripping of these two breakers might occur. Steady lamp load, thus, is $0.035 \text{ A} \times 3 = 0.105$ amperes. Maximum short-time loads, given for both 48-volt and 125-volt dc to illustrate procedure, are:

Control voltage, dc	48 V	125 V
Trip coil current	6 A	3 A
Charging motor current	16 A	8 A

Since two breakers can trip at once, maximum current from this load is either $6 \text{ A} \times 2$, or $3 \text{ A} \times 2$, respectively, 12 or 6 amperes at 48 or 125 volts. Comparing this with charging motor current, we see that the latter is larger, so motor current will be used in the next step as illustrated in Table 4-5.

Table 4-5

Battery type:	Lead-acid		Nickel-cadmium	
Control voltage (volts)	48	125	48	125
Maximum 1-minute demand (amperes)	16	8	16	8
8-hr. equiv. of 1-min. demand (Max. demand divided by conversion factor*) (ampere-hours)	10.7	5.4	5.5	2.8
Lamp load (0.105A x 8 hrs.) (ampere-hours)	0.84	0.84	0.84	0.84
Total ampere-hours (8 hr. rate)	11.54	6.24	6.34	3.64

*Conversion factors to convert to "common rate base" (i.e., from one-minute rate to eight-hour rate) are: 1.5 for the lead-acid batteries (pasted plate); 2.9 for the nickel-cadmium batteries (thin plate or high rate). Please note that conversion factors vary by cell size; therefore, the factors used in this example are not applicable for batteries of other sizes.

Analyzing these totals, the minimum size cell is more than sufficient at 48 volts and at 125 volts, for either battery type. In addition, since the total ampere-hours required in each case is less than the ampere-hour capacity of the minimum size cell, reserve capacity is available. The matter of reserve capacity is largely related to how long the charger may be off. This no-charge condition has been known to last for several days. Thus, a "dc low-voltage alarm" option in the charger may be desirable to warn of such conditions.

For the same station, with the battery at outdoor temperatures, the one-minute demand must be doubled before converting to ampere-hours. The eight-hour rate needs a smaller increase of about 30 percent. Note that these conversion ratios generally decrease as cell size increases; hence, the approximate size of cell being considered must be determined before the conversion factors can be determined.

Battery Chargers

Battery chargers have been built both as unregulated or "trickle" chargers, and as voltage-regulated

chargers. The latter type provides longer life for the battery, particularly if it is a lead-acid battery. Voltage-regulated chargers are considered standard for switchgear applications.

The charger must be selected with an ampere rating sufficient to satisfy the simultaneous demand of the following three functions:

- Self-discharge losses of the battery.
- Steady load of the station: indicating lamps, etc.
- Equalizing charges, or other high-rate output requirements.

The self-discharge or "trickle" current of a lead-acid battery starts at about 0.25 percent of the eight-hour rate, and increases with age to about 1.0 percent of that rate. Nickel-cadmium cells can be assigned a similar trickle current.

Steady load is made up of the long-time loads mentioned earlier in this section.

Equalizing charge is a monthly requirement for lead-acid batteries except for the lead-cadmium class. When the charger is first switched to the higher equalizing voltage, the battery demands current equal to about 20 percent of its eight-hour rate. Nickel-cadmium batteries do not require equalizing, but it is convenient to use the same numbers as for lead-acid in establishing the charger capacity to be used for occasional "boosting" of the nickel-cadmium battery.

In sizing the charger, the first number considered should be the steady load from the preceding battery calculations. Add to this load the equalizing charge current. A quick way to find equalizing amperes is to divide the battery ampere-hour capacity (at the eight-hour rate) by 40. The sum of steady load and equalizing amperes is then compared with a list of battery charger ratings; select a charger with a rating that equals or exceeds this sum. The trickle current, unless known to be quite large, is usually covered by the margin between the standard charger rating and the sum of steady and equalizing loads.

Occasionally a battery is shipped "dry", with electrolyte added at its destination. Such batteries require a "conditioning" charge after filling; the amperes needed for this are 25 percent of the eight-hour rate, but with no other load connected.

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AC CONTROL POWER EQUIPMENT

Application

To minimize the possibility of inadvertent interruption of control power for ac operated POWER/VAC switchgear, it is recommended that control power be derived from a separate transformer used only for control and other power requirements, which are directly associated with the performance of the switchgear. The transformer should be energized from that part of the main power system least likely to be de-energized.

Where the switchgear is energized from multiple sources of power, a control-power transformer is usually provided for each source, for operation of breakers associated with that source. Breakers such as feeder and bus-tie breakers not associated exclusively with any one source are supplied either from a transformer connected to the switchgear bus, or by selective relays embodied in the control power equipment, which automatically connect the control bus to an energized transformer.

Selection

If breaker tripping power, with ac control, is being obtained from capacitor-trip devices, its demand need not be included in the transformer section. Similarly, closing demand is relatively small, except for the breaker spring-charging

motors. The principal caution regarding closing demand is to review for conditions where two or more spring-charging motors may be energized at the same time.

Other loads, such as those listed on page 4-2, must be totalled and evaluated to determine their demand on the transformer. The total load is then compared to the available sizes of control power transformers, and the next larger size selected.

As an example, consider an outdoor, protected-aisle station having five breakers and one auxiliary compartment (in four vertical sections). Control of breakers is from local control switches. No ventilating fan is used, but 400 Watts are needed for remote lights. As shown in Table 4-6, the load is approximately 7 kVA, so the next larger available transformer (10 or 15 kVA) is selected.

Table 4-6

Type of Load	Load (VA)
Indicating lamps (0.035A x 230V x 5 Breakers)	40
Equipment heaters (300 W x 4)	1200
Comfort heater (plug in)	5000
Equipment lights (100 W x 4)	400
Convenience outlets (500 W x 2)	1000
Remote lights	400
TOTAL	8040

Section 5

System and Equipment Protection

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System and Equipment Protection

INTRODUCTION

This section covers some of the basic considerations used when selecting equipment for protection, control instrumentation, metering, and control power protection.

Protection considerations include phase and ground directional and non-directional, overcurrent relaying, differential relaying, directional power relaying, underfrequency relaying, and under-voltage relaying.

Instrumentation, metering, current and voltage detection considerations include selection of scales as well as instrument transformer ratios.

Control considerations include a discussion of permissive control operation as well as supervision of trip coils by indicating lamps.

Since all ac power systems are subject to transient voltages, a discussion of surge protection is also included.

PROTECTION CONSIDERATIONS

BASIC SYSTEM PROTECTION

Phase-overcurrent Protection

Recommended phase-overcurrent protection consists of one phase-over-current relay Type IFC in each phase operated from a current transformer in each phase. This arrangement provides complete circuit phase-overcurrent protection when one phase relay is removed from the circuit for testing; it also provides local backup if one of the three phase relays is inoperative. Minimum phase-overcurrent protection available for feeders, when ground protection is included, consists of two phase-overcurrent relays operating from current transformers in phases one and three. However, this minimum arrangement does not provide phase backup protection if one phase relay is removed from the circuit.

Overcurrent relays are available with inverse, very inverse, or extremely inverse characteristics. In the absence of additional system information, the very inverse characteristic is most likely to provide optimum circuit protection and selectivity with other system protective devices. If selectivity with fuses and reclosers is a requirement, the extremely inverse characteristic is well suited for application. The inverse characteristic is useful in those rare applications in which selectivity with other inverse or definite time relays is a concern. It is also useful on systems that have a multiplicity of local generators at the distribution voltage and where the magnitude of fault current is determined primarily by how many generators are in service at the time.

INCOMING LINES — Incoming line phase-over-current relays (51) are usually furnished without instantaneous attachments (50) to be selective with

feeder relays having instantaneous attachments (50/51).

FEEDERS — Instantaneous phase-overcurrent relay (50) settings for radial *utility distribution feeders* are set usually as low as possible considering, among other things, "cold-load" pickup and other circuit requirements. Instantaneous phase-overcurrent relays for *industrial or commercial building radial circuits* are usually set high enough (but well below the available short-circuit current) to prevent false tripping for faults at the lower-voltage terminals of large transformer banks and to provide selectivity with groups of large motor starters. Instantaneous settings should be low enough so that the combination of time and instantaneous settings provides protection below the conductor short-circuit heating limit.

FEEDER TIES — For feeder-tie circuits to *downstream* distribution circuit-breaker lineups, selectivity is enhanced by disconnecting the instantaneous element (50) of the phase-overcurrent relays and setting the time-overcurrent relay (51) element to trip at less than the short-circuit heating limit of the conductors.

BUS TIES — Bus-tie circuits, within the same lineup of switchgear including two incoming lines, are frequently specified without overcurrent-protective relays. When overcurrent protection is provided for this type of circuit, relays are connected in what is termed a "summation over-current" connection. The use of this connection provides the opportunity for selectivity between main or tie breakers and feeder breakers minimizing relay operating time delay. (See the one-line diagram on pages 2-6 and 2-7 for an example of this connection.)

TRANSFORMERS — Transformer-overcurrent protection criteria are specified in Section 450-3 of the 1975 National Electrical Code. Permissible short-circuit capabilities for transformers are specified in American National Standards Institute Standard C57.12-1968, Paragraph 10.1.1. Selection of transformer-overcurrent protection is governed by these criteria.

The NEC requirements determine the pickup of the time-overcurrent phase protective relays. The ANSI requirements and the connection of the transformer determine the time dial setting. The inrush and short-circuit current magnitudes determine the instantaneous setting of the phase-overcurrent protective relays.

GENERATORS — Overcurrent relays, applied on generator circuits, are used for feeder backup rather than overload protection. These overcurrent relays are Type IJCV voltage-restrained overcurrent relays (51 V). They operate faster and are more sensitive for faults close to the generator than for faults remote from the generator.

Ground-overcurrent Protection

Ground-overcurrent protection is provided by either Type IFC time-overcurrent relays or Type HFC instantaneous overcurrent relays. Sensitive ground-fault protection is desirable to minimize damage to circuit equipment and circuit conductors.

The three most commonly used connections for ground-overcurrent relays are the residual connection (51N), the ground-sensor (balanced-flux or zero-sequence) connection (50GS or 51GS), and the neutral current transformer connection (51G).

Residually connected ground-overcurrent relays (51N) are wired in the ground-return current transformer lead of three current transformers connected in wye. The relay detects the current in the ground fault by measuring the current remaining in the secondary of the three phases of the circuit as transformed by the current transformers. The minimum pickup of the relay is determined by the current transformer ratio. On systems with line-to-neutral connected loads, the ground-overcurrent relay (51N) pickup must be set above any expected maximum single-phase unbalanced load. If an instantaneous ground-overcurrent relay (50N) is used, it must be set above any expected unbalance due to unequal current transformer

saturation on phase faults or transformer inrush currents.

Ground-sensor relaying schemes use an instantaneous (50GS) or time-delay (51GS) overcurrent relay connected to the secondary of a window-type current transformer through which all load current carrying conductors pass. The relay detects the ground current directly from this current transformer provided the equipment ground conductor and cable shielding bypass the current transformer. A 50:5 current transformer and 0.5A instantaneous or time-delay relay detects faults as low as 15 amperes in the primary circuit.

Neutral ground relaying uses a time-delay overcurrent relay (51G) connected in the secondary of the current transformer located in the neutral of a wye-connected transformer, wye-connected generator, or the neutral of a neutral deriving transformer bank.

INCOMING LINES — Incoming line ground-overcurrent relay protection consists of either a residually connected relay (51N) or a relay (51G) connected to a current transformer in the transformer neutral ground connection. Ground-sensor relaying (51GS) on incoming lines is rarely applicable because of the size, number, or construction of the incoming line conductors.

For solidly grounded systems with remote-supply transformers, residually connected ground-overcurrent relays (without instantaneous attachments) are most applicable. Some utility users omit all incoming line ground relays on solidly grounded systems and rely on three phase-overcurrent relays to provide complete phase- and ground-fault protection.

For impedance-grounded systems with local supply transformers, a ground relay (51G) connected to a current transformer in the transformer neutral connection is most applicable. A typical current transformer ratio for the neutral current transformer is one-half to one-quarter the maximum ground-fault current, i.e., a 200:5 CT ratio is appropriate for the neutral CT in series with a 400A, 10-second neutral grounding resistor. This ratio permits sensitive settings of the ground relay and selective operation with downstream ground-sensor relays. The ground relay is the system backup relay for the medium-voltage system. It also provides ground-fault protection for the transformer and its secondary conductors. If a trans-

System and Equipment Protection

former primary circuit breaker is used, the secondary ground-overcurrent relay (51G) in the transformer neutral connection should trip both the transformer primary and secondary circuit breaker.

FEEDERS — Ground-sensor (zero-sequence) relay arrangements use instantaneous-overcurrent relays (50GS) or time-overcurrent relays (51GS) and are appropriate for both impedance and solidly grounded systems. These arrangements provide sensitive ground-fault protection for both branch circuits and feeder-distribution circuits. Good selectivity can be obtained for a distribution system incorporating this type of relaying on all branch and feeder distribution circuits; however, a feeder breaker with ground-sensor relaying usually cannot be made selective with downstream feeders using residual ground relaying. In addition, ground-sensor relaying is not applicable to circuits with metal-enclosed conductors because of the impracticability of passing the phase conductors through a single current transformer. Ground-sensor relaying is rarely applied to circuit terminated with pot-heads because of the special installation procedures required for mounting the pot-heads. Further, instantaneous ground-sensor relaying is not normally applied on distribution circuits with surge arresters on the load side of the ground-sensor current transformer. This prevents relay operation every time an arrester operates.

Residual-ground relaying (51N or 50/51N) is suitable for feeders on solidly grounded systems or impedance grounded systems with available ground-fault currents greater than about twice the maximum current transformer rating. It is also required for feeders which must be selective with downstream feeders, which have residual-ground overcurrent relaying.

TRANSFORMERS AND GENERATORS — Ground-overcurrent relaying for wye-connected transformers, wye-connected generators and neutral-deriving transformers usually employs neutral-ground relaying, as discussed previously under "Incoming Lines". This provides system backup ground relaying. Settings, however, are normally too high to provide good ground-fault protection for the apparatus. Ground-fault protection is better obtained by using a scheme of differential relaying which is described later in this section.

Directional Phase-overcurrent Protection

Directional phase-overcurrent relays (67) operate for current flow in only one pre-determined direction. Incoming lines, operating in parallel from separate sources, require directional phase-overcurrent relay protection to provide sensitive operation and to assure selectivity between incoming-line breakers for phase faults on the source side of one of the breakers. This directional phase-overcurrent protection is furnished by using the Type IBC or JBC relay, polarized to operate on current flowing toward the source. The IBC relay, without instantaneous attachment, is appropriate for most applications. The pickup of this relay should be set at a value slightly below full-load current. The time dial can be set to permit selectivity with upstream feeder breaker or line instantaneous relays.

Occasionally a Type JBC directional-overcurrent relay (67) with directional instantaneous unit is applied to incoming lines fed by long "dedicated" service incoming lines or large local transformer incoming lines. For long "dedicated" service lines, the instantaneous directional unit is set to operate for faults located approximately 80 to 90 percent of the distance from the incoming line to the source. For large local transformers, the instantaneous unit is set slightly above the low-voltage symmetrical rms amperes contributed through the transformer to a fault on the higher voltage side of the transformer.

Directional phase-overcurrent relays can be voltage polarized from bus PT's connected in open-delta, delta-delta or wye-wye. Polarization is necessary to establish the current phase relationships between voltage and current to determine the direction of current flow.

Directional Ground-overcurrent Protection

Incoming lines operated in parallel from separate grounded sources require directional-ground-overcurrent relays (67N) to assure selectivity between incoming-line breakers for ground faults on the source side of each of the incoming-line breakers. For solidly grounded systems and many impedance-grounded systems, the Type IBCG relay usually is appropriate. This relay is set at a low pickup to permit selectivity with the other incoming-line non-directional ground-overcurrent relaying.

All directional-ground relays must be polarized. For systems with local, grounded supply transformers, the current transformer located in the transformer neutral-ground connection may be used for polarizing. For systems with remote-supply transformers, a set of local wye-wye connected potential transformers (or wye-wye PT's with wye-broken delta auxiliary transformers) may be used for polarization. On occasion, dual polarization may be desirable.

Differential Protection

Differential protection is a method of apparatus protection in which an internal fault is identified by comparing electrical conditions at all terminals of the apparatus.

BUS PROTECTION — Bus-differential relays should be applied to generator buses, buses with high available short-circuit current, and buses which, if faulted, create system disturbances which could lead to system instability in other portions of the system if the fault is not rapidly isolated. This type of relaying uses equally rated phase-current transformers of like characteristics in each circuit connected to or from the bus to be protected. Bus-differential relays (87B), Type PVD, are high-speed relays sensitive to both phase and ground faults.

TRANSFORMER PROTECTION — Transformer-differential relays (87T), Type STD, are high-speed relays with harmonic restraint. These relays use current transformers of different ratios and connections and compensating relay taps. Liquid-filled transformers, larger than approximately 5000 kVA, are protected usually with both differential and fault-pressure relays (63FP) and occasionally with gas-detector relays.

Differential relays protect the transformer circuit, including conductors, bushings and windings. High-speed relays, Type STD, are normally applied since slower induction-disc differential relays are no better than conventional overcurrent protection and must be desensitized against transformer inrush currents. Fault-pressure relays provide excellent internal tank-fault protection for liquid-filled transformers, but do not include the entire circuit in the protected zone.

Transformers connected delta-wye, with the secondary neutral grounded through resistance, frequently require ground-fault as well as phase-

fault-differential protection because the pickup of phase-differential relays may not be low enough to detect secondary ground faults. This results from the large CT's necessary to carry transformer lead currents at forced ratings. For such systems, either a differentially connected Type IFC ground-overcurrent relay with a very inverse characteristic, an IFD differential relay with restraint coils, or an ICC product directional relay with its operating coil differentially connected and its polarizing coil connected to a neutral CT can be used to complete the protection.

MOTORS — Motor differential relays are usually applied to motor circuits for motors 1500 hp and larger. Motor-differential three-phase relays (87M), Type HFC used for this application employ the balanced-current principle. This type of protection provides for detecting motor-fault currents as small as 15 amperes. An example for a typical application is shown in the one-line diagram in Section 2. In some applications, Type IJD or CFD differential relay schemes are used to protect both the motor and its feeder cable. These schemes use three CT's on each side of the motor.

LINES — Line-differential protection for short lines and important tie lines between medium-voltage switchgear lineups is obtained by using Type CPD (87L) pilot-wire relays. These relays compare the currents at each end of a two-terminal line. These high-speed relays are sensitive to both phase and ground faults. Pilot wire supervision and transfer tripping employ Type BBA relays in conjunction with the pilot-wire relays.

GENERATORS — All generators should be protected with differential relaying. Generator-differential relays (87G) Type CFD are high-speed relays sensitive to phase faults and many ground faults. These relays compare the currents in and out of generators using three CT's on each side of the generator. For small generators, balanced-current-differential relaying may be used. This type of relaying is described under "Differential Protection — Motors".

Open-phase Protection (Negative-sequence Voltage)

Incoming line open-phase operation occurs when one conductor is opened due to either a single fuse melting or a single-line conductor or circuit breaker pole opening. System protection for either of these events for systems without local generation consists of a negative-sequence voltage unbalance relay

System and Equipment Protection

Type NBV (60). To avoid tripping on system transient disturbances, this relay should operate through a timer usually set from 2 to 4 seconds. For systems subject to harmonics, apply a harmonic filter to the input to this relay.

Automatic Reclosing

Radial feeders supplying overhead lines, with or without line sectionalizing, sometimes employ automatic reclosing for better service continuity. Relaying for this type of application is used for open-wire overhead circuits which are prone to develop non-persistent faults. A series of three attempts to close a breaker at variable times may either be programmed with an immediate initial reclosure or an initial time-delay reclosure. The Type NLR relay (79) is appropriate for this function. The use of the immediate initial reclosure option is not recommended on feeders serving large motors or on feeders originating on a generator bus. Frequently, the automatic reclosing relay is used to block an instantaneous overcurrent relay (50 or 50N) after the initial trip for part or all of the reclosing schedule.

Directional Power, Underfrequency, and Undervoltage Protection

Systems with local generation or large motors require relaying to detect fault conditions on the utility tie circuit or to detect loss of the utility source. Relays used to detect these circumstances should be high-speed to trip the utility tie prior to any automatic reclosing operations and to promptly initiate any programmed load shedding. Complete protection for these circumstances is provided by a combination of relays including an underfrequency relay (81), Type SFF; sensitive directional-power relay (32), Type CCP; and an undervoltage relay (27), Type NGV. For some applications, a timer is also used which is set at about 0.2 second. The directional-power relay may be connected to current transformers either in the incoming line circuit or in a large-motor circuit depending on the application. A study of the specific system is required to select the appropriate relays and connections for this type of protection.

BASIC EQUIPMENT PROTECTION

Circuit Breaker Control and Control Power Protection

Basic circuit breaker control consists of a control switch, located at the breaker to close and trip

the breaker. Associated with the control switch are two indicating lamps, one red and one green. The red lamp indicates a closed breaker. This lamp is connected at the end of the relay trip-contact chain in series with the breaker trip coil and supervises not only the trip coil, but also the relay trip circuit wiring. The green lamp indicates an open breaker. This lamp is connected through a breaker "b" contact.

Each breaker trip circuit is individually protected by a two-pole 60-ampere pullout fuse-block with 35-ampere NEC fuses. The same type of pullout fuse-block rated 30 amperes is used with 15-ampere fuses for each individual closing circuit.

An optional white "breaker disagreement" lamp is available. This lamp is by-passed by a slip contact of the control switch and connected to a "b" contact of the breaker and provides indication of a breaker opening not initiated by the control switch. An alternate option for this white lamp is to provide indication of the circuit breaker spring-charged condition.

For switchgear applications requiring remote control, a permissive control function is available. This function provides local or remote control of a circuit breaker under certain defined conditions, and is available in three schemes as shown in Table 5-1.

Scheme C is recommended for remote control, since it provides maximum operating flexibility. When a local "trip" operation is initiated, the breaker cannot be closed remotely until the local switch handle is returned to the "NORMAL AFTER CLOSE" position. When the breaker is in the "TEST" position, closing and tripping can only be done locally.

Instrumentation, Current, and Potential Transformers

INSTRUMENTS — Basic current indication in POWER/VAC switchgear uses a 240-degree scale taut-band, Type AB-40, indicating ammeter with one percent accuracy at full scale, plus a transfer switch. An optional substitution of three ammeters instead of an ammeter and switch may be made. Also, a three-element, horizontal, Lincoln thermal demand ammeter with instantaneous attachment may be substituted for three ammeters.

Table 5-1. Remote Control Schemes

Control Location		Local				Remote				Devices Required (in addition to remote CS)
Breaker Operation		Close		Trip		Close		Trip		
Breaker Position		Conn	Test	Conn	Test	Conn	Test	Conn	Test	
Remote Control Schemes†	A			x	x	x	x	x	x	Local permissive sw (69) in lieu of control sw (CS)
	B		x		x	x		x		Local control sw (CS), plus bkr position sw
	C*		x	x	x	x		x		Local control sw (CS), plus bkr position sw

X = This manually initiated operation is possible.

* This scheme uses same devices as scheme B, but different wiring.

† The basic control scheme provides only local control, as follows:

Basic Control	x	x	x	x						Control sw (CS)
---------------	---	---	---	---	--	--	--	--	--	-----------------

Optional voltage indication can be maintained using a Type AB-40 indicating voltmeter and transfer switch.

Optional wattmeters and varmeters Type AB-40 are available for most equipments.

SCALES, CURRENT TRANSFORMER, AND POTENTIAL TRANSFORMER RATIOS — The ammeter scale is determined by the CT ratio. Current transformer ratings are normally selected to exceed slightly the ampacity of the feeder circuit conductors. Current transformer ratios selected in this manner permit settings of circuit overcurrent-protective relays which provide good selectivity and protection. For a properly designed circuit, operating at full load, this means a maximum scale reading of between half and three-quarter scale. For a circuit which provides for substantial future expansion, lower scale readings will indicate initial light-load conditions.

The voltmeter scale, determined by the potential transformer ratio, is 125 percent of the nominal line-to-line PT rating.

Wattmeter and varmeter scales are determined by the CT and PT ratios.

CURRENT TRANSFORMERS AND POTENTIAL TRANSFORMERS — Basic window-type current transformers for phase conductors listed in Device Table 7-33 are available in ratios ranging from 150:5 to 3000:3.75 (effective 4000:5 ratio) amperes. The basic ground-sensor window-type CT ratio is 50:5 amperes, with a seven-inch window,

and is listed in Table 7-34. An optional current transformer with a 12-inch window is available for circuits with a large number of conductors. Low current wound primary CT's are listed in Table 7-35.

Excitation characteristics and accuracy classes are given in Tables 7-33, 7-34, and 7-35.

Basic potential transformers are listed in Tables 7-37 and 7-38, along with the appropriate volt-ampere burden characteristics.

Instrument transformer metering accuracies are of concern for billing metering applications. Current transformer relaying accuracies and excitation characteristics are particularly important when considering lower-rated current transformers on systems with high available short-circuit currents and for all differential relay applications.

TRANSFER SWITCHES — The basic ammeter transfer switch is a Type SB-1 switch arranged for middle of the circuit connection. This permits the addition of other secondary devices to the circuit at a future date. It includes positions for reading all three phases plus OFF. The basic voltmeter switch, Type SB-1, includes positions to read phase-to-phase voltage plus OFF.

Metering and Test Blocks

Optional two-element watthour meters or two-element watthour demand meters are available. These devices are for application on circuits with line-to-line connected loads. If two-element meters

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are applied on circuits with line-to-neutral connected loads, the amount of load unbalance between phases can cause a proportional inaccuracy in the meter reading. For these applications, a two and one-half or three-element meter is more appropriate. The basic demand interval is 15 minutes. Basic meters are secondary reading utilizing a multiplier equal to the current transformer ratio times the potential transformer ratio.

Four-pole Type PK test blocks and plugs can be furnished to facilitate circuit testing, using portable instruments and meters. The current test block is arranged so that the current circuit is maintained when the plug is removed from the block.

SURGE PROTECTION

Every medium voltage ac power system is subject to transient voltages in excess of the normal operating voltages. There are many sources of transient voltages.

The most prominent ones are:

- Lightning
- Physical contact with a higher voltage system.
- Resonant effects in series inductive-capacitive circuits.
- Repetitive restrike (intermittent grounds).
- Switching surges.

To mitigate the effects of these transient voltages, both surge arresters and, where appropriate, surge capacitors should be used. Surge arresters limit the crest voltage of a voltage surge; surge capacitors reduce the steepness of the voltage wave

which reaches the protected equipment.

Surge capacitors, to be most effective, should be located as close to the protected equipment (usually motors) as possible with minimum inductance connections.

Surge arresters can be supplied with certain POWER/VAC units (namely, SSIL, DSIL, BE and GEN) to limit the peak magnitude of transient voltage at loads to values below the rated BIL level of connected utilization equipment.

Those pre-engineered units which do not include surge arresters as a standard option are supplied with surge suppressors. For equipment with surge suppressors, the peak transient line-to-ground voltages which can appear across the load side of the breaker during the application of a 10,000-ampere 8 x 20-microsecond lightning surge to the surge suppressors, are those shown in Table 5-2. Furthermore, because switching surges deliver significantly less than 10,000 amperes, all peak transient voltages caused by switching operations will be significantly less than the values shown in Table 5-2.

Table 5-2. Peak Transient Line-to-Ground Voltages

System Voltage (kV)	Switchgear Equipment BIL (kV)	Maximum Line-to-Ground Voltage (kV)
4.16	60	11
7.2	95	22
13.8	95	33

Section 6

POWER/VAC Switchgear Equipment

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POWER/VAC Switchgear Equipment

INTRODUCTION

This section contains detailed information covering structured device packages for POWER/VAC® metalclad switchgear equipment. With this information, complete specifications for a lineup of metalclad switchgear can be developed.

The first part of this section contains basic equipment specifications for the protection, instrumentation, and control portions of the equipment. Thirteen basic circuits are shown in detail, complete with the model numbers of the basic equipment and devices for these commonly used configurations. For each circuit, a discussion of options is included with illustrations of some of the optional arrangements. Following the specifications for each of the circuits are option tables for substitutions, omissions, and additions to the basic structured equipment. A series of tables giving arrangements of power conductor and auxiliary compartments follows this data. The last part of this section shows a sample lineup developed from the preceding information.

Section 7 of this guide contains a device list giving the ratings and characteristics of the devices included in Section 6.

Devices illustrated in Section 6 utilize an 125V dc control voltage. (Devices with optional control voltages are given in Section 7.)

To use Section 6, proceed in the following manner:

- Determine the type of each circuit in the one-line diagram (developed in accordance with procedures outlined in Section 2).
- Select from the 13 basic circuit specifications

the circuits which meet the requirements of the installation.

- Study the discussion on selection of options for each circuit for which options may be required. Refer to the device list in Section 7 for the description, ratings, and characteristics of any device included in the basic equipment or optional equipment.
- Select from the option tables those options desired for the protection, instrumentation, and control portion of each circuit.
- Determine the requirements for auxiliary compartments to house potential transformers or control power transformers.
- Determine the incoming and outgoing circuit conductor configurations required for each circuit.
- Select the equipment configuration necessary for each circuit and auxiliary compartment from the part of this section covering Power Conductor and Auxiliary Compartments (pages 6-43 to 6-53).

The basic equipment and options in this section constitute a structured line of metalclad equipment. Some lineups, however, may require devices and circuit arrangements other than those included in this section. These items are considered custom fabricated items. Custom requirements are discussed in Section 9.

To obtain the maximum benefits of prompt engineering service, consistency of circuit and device arrangement, and minimum number of equipment variations, specify as much of a lineup as possible from Section 6.

BASIC EQUIPMENT APPLICATIONS

DEFINITION

A brief definition of each of the 13 basic equipments is given in the following paragraphs.

GENERAL PURPOSE FEEDERS

General purpose feeder (GPF) equipment is metalclad equipment controlling and protecting a set of conductors supplying one or more secondary distribution centers, one or more branch-circuit distribution centers, or any combination of these two types of equipment. A general purpose feeder usually includes circuit overcurrent protection, circuit current indication, and circuit control.

BREAKER BYPASS FEEDERS

Breaker bypass feeder (BBF) equipment is metalclad equipment similar to a general purpose feeder, except two breaker units are connected in parallel to feed a common load. Phase current transformers from both circuit breakers are connected in parallel to a common set of phase relays and instruments. This arrangement is used when a means to bypass a feeder circuit breaker is desired. Every breaker bypass position on every feeder does not necessarily include a circuit breaker removable element. One spare circuit breaker removable element per lineup or bus section is usually considered sufficient for each equipment lineup.

TRANSFORMER PRIMARY FEEDERS

Transformer primary feeder (TPF) equipment with differential relays is similar to a general purpose feeder except the entire load is one transformer, and the entire circuit is protected with transformer differential relays. Liquid transformers of the rating to justify differential protection for the circuit are usually equipped with fault-pressure relays for additional internal protection. Both the differential and fault-pressure relays trip a hand reset lockout relay which trips the primary and secondary transformer circuit breaker.

SINGLE-SOURCE INCOMING LINES

Single source incoming line (SSIL) equipment is metalclad equipment for a circuit to a main power distribution bus from the only source of power supplying the bus. A system with this type of incoming line is called a radial system. A system with two or more incoming lines supplying distribution buses sectionalized by normally open bus-tie circuit breakers require the same type of protection, instrumentation, and control as single source incoming lines, with the possible exception of the connection of the overcurrent relays.

DUAL SOURCE INCOMING LINES

Dual source incoming line (DSIL) equipment is metalclad equipment for a circuit to a main power distribution bus from one or two sources of power supplying the main bus. The other source of power may be either another incoming line or a local generator. Both sources supply a common distribution bus with or without a normally closed bus-tie circuit breaker.

BUS TIES

Bus tie (BT) equipment is metalclad equipment connecting two power distribution buses with a tie breaker. Such equipments are usually not equipped with overcurrent relays because of the difficulty of obtaining selective system operation with bus-tie overcurrent relays.

BUS ENTRANCES

Bus entrance (BE) equipment is a metalclad vertical section in which one of the compartments contains incoming conductors which are connected directly to the main bus. No incoming breaker is used. This arrangement applies to lineups of switchgear, without main circuit breakers, which connect the incoming line to the main bus. It also applies to subfeeds, from a lineup of switchgear without circuit breakers, which connect the outgoing conductors to the main bus.

POWER/VAC Switchgear Equipment

INDUCTION MOTOR FEEDERS, FULL-VOLTAGE-START, ESSENTIAL SERVICE, ALL RATINGS

These metalclad feeder (IMFE) equipments are used for controlling and protecting full-voltage-start, essential-service motors and are designated as motor "branch circuit" protective equipment. ("Branch circuit" is defined in Article 100 of the 1975 National Electrical Code.)

INDUCTION MOTOR FEEDERS, FULL-VOLTAGE-START, LESS THAN 1500 HP

These metalclad feeder (IMF1) equipments are used for controlling and protecting full-voltage-start motors of less than 1500 hp and are designated as motor "branch circuit" protective equipment.

INDUCTION MOTOR FEEDERS, FULL-VOLTAGE-START, 1500 HP AND LARGER

These metalclad feeder (IMF2) equipments are used for controlling and protecting full-voltage-start motors of more than 1500 hp and are designated as motor "branch circuit" protective equipment. These equipments include differential protection.

SYNCHRONOUS MOTOR FEEDERS FULL-VOLTAGE-START, LESS THAN 1500 HP

These metalclad feeder (SMF1) equipments are used for controlling and protecting full-voltage-start synchronous motors of less than 1500 hp and are designated as motor "branch circuit" protective equipment.

SYNCHRONOUS MOTOR FEEDERS FULL-VOLTAGE-START 1500 HP AND LARGER

These metalclad feeder (SMF2) equipments are used for controlling and protecting full-voltage-start synchronous motors of more than 1500 hp and are designated as motor "branch circuit" protective equipment. These equipments include differential protection.

GENERATORS

This metalclad generator (GEN) equipment controls and protects a synchronous generator driven by a gas turbine or diesel engine.

GENERAL PURPOSE FEEDERS

DEFINITION

A general purpose feeder equipment (GPF) is a metalclad equipment controlling and protecting a set of conductors supplying one or more secondary distribution centers, one or more branch-circuit distribution centers, or any combination of these centers.

BASIC EQUIPMENT SELECTION

GPF-1 Use this type of feeder for systems which are impedance or solidly grounded and for which selectivity is not required with downstream residually connected ground relays.

This type of feeder equipment includes three Type IFC phase-overcurrent relays

(50/51) and one Type HFC ground-sensor instantaneous overcurrent relay (50GS).

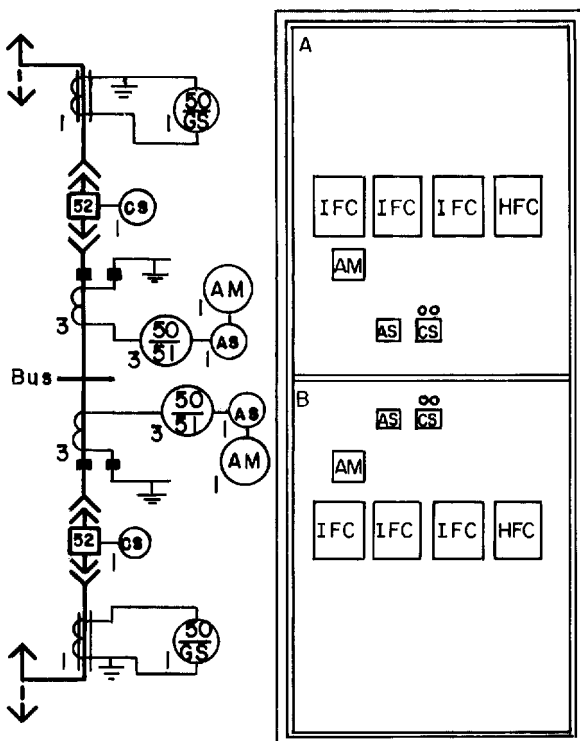
GPF-2 Use this type of feeder for systems which are impedance or solidly grounded and for which selectivity is required with downstream residually connected ground relays.

This type of feeder equipment includes three Type IFC phase-overcurrent relays (50/51) and one Type IFC residually connected time-overcurrent ground relay (51N).

GPF-3 Use this type of feeder for ungrounded or solidly grounded systems for which no ground relays are desired.

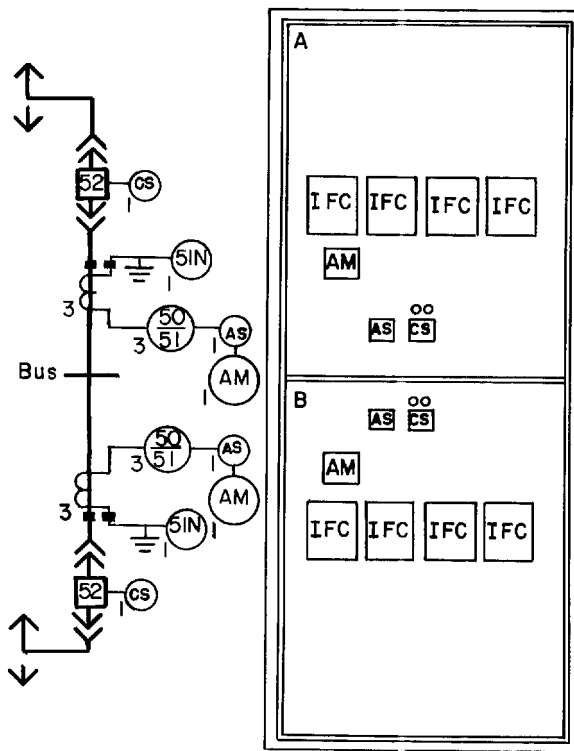
This type of feeder equipment includes three Type IFC phase-overcurrent relays (50/51) and no ground relays.

GENERAL PURPOSE FEEDER (GPF-1)

DEVICE LIST FOR GPF-1
(Unit A or Unit B)

Device	Device No. or Abbr.	Qty	Description or Model No.
Power Circuit Breaker	52	1	VB - (kV) - (MVA) - (A)
Phase Overcurrent Relays	50/51	3	12IFC53B1A
Ground Sensor Relay	50GS	1	12HFC11B1A
Current Transformers	CT	3	JAG-0 (___/5A)
Current Transformer	CT	1	Tech-Tran G.S.
Breaker Control Switch	CS	1	16SB1B9X2
Indicating Lights	IL	2	ET-16, 125V (1-R,1-G)
Breaker Closing Fuse Pullout	FU	1	2P-30A (15A Fuses)
Breaker Tripping Fuse Pullout	FU	1	2P-60A (35A Fuses)
Ammeter (Scale to Match CT)	AM	1	AB-40
Ammeter Switch	AS	1	16SB1CA15X2
Provision for Power Conductor Terminations (NEMA Drilling Only)	—	2	Per phase

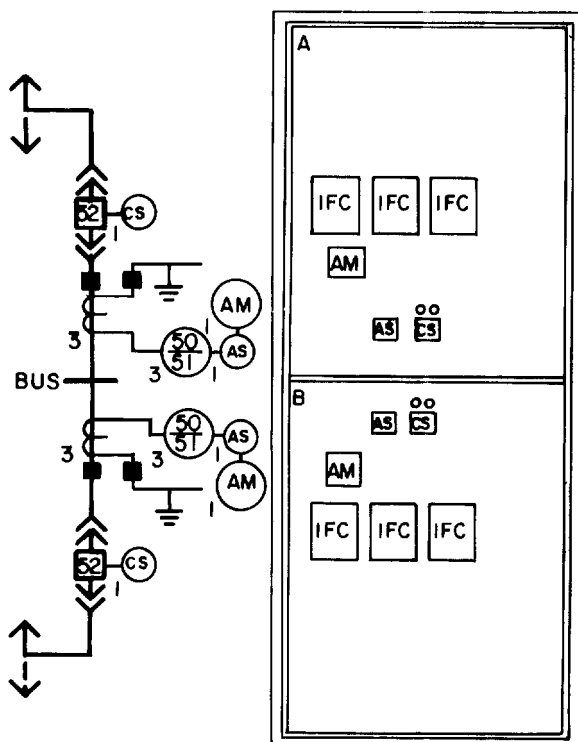
GENERAL PURPOSE FEEDER (GPF-2)



DEVICE LIST FOR GPF-2 (Unit A or Unit B)

Device	Device No. or Abbr.	Qty	Description or Model No.
Power Circuit Breaker	52	1	VB - (kV) (MVA) (A)
Phase Overcurrent Relays	50/51	3	12IFC53B1A
Residual Overcurrent Relay	51N	1	12IFC53A2A
Current Transformers	CT	3	JAG-0 (/5A)
Breaker Control Switch	CS	1	16SB1B9X2
Indicating Lights	IL	2	ET-16, 125V (1-R,1-G)
Breaker Closing Fuse Pullout	FU	1	2P-30A (15A Fuses)
Breaker Tripping Fuse Pullout	FU	1	2P-60A (35A Fuses)
Ammeter (Scale to Match CT)	AM	1	AB-40
Ammeter Switch	AS	1	16SB1CA15X2
Provision for Power Conductor Terminations (NEMA Drilling Only)	—	2	Per phase

GENERAL PURPOSE FEEDER (GPF-3)



DEVICE LIST FOR GPF-3 (Unit A or Unit B)

Device	Device No. or Abbr.	Qty	Description or Model No.
Power Circuit Breaker	52	1	VB - (kV) (MVA) (A)
Phase Overcurrent Relays	50/51	3	12IFC53B1A
Current Transformers	CT	3	JAG-0 (/5A)
Breaker Control Switch	CS	1	16SB1B9X2
Indicating Lights	IL	2	ET-16, 125V (1-R,1-G)
Breaker Closing Fuse Pullout	FU	1	2P-30A (15A Fuses)
Breaker Tripping Fuse Pullout	FU	1	2P-60A (35A Fuses)
Ammeter (Scale to Match CT)	AM	1	AB-40
Ammeter Switch	AS	1	16SB1CA15X2
Provision for Power Conductor Terminations (NEMA Drilling Only)	—	2	Per phase

OPTIONAL EQUIPMENT SELECTION**Protection**

OVERCURRENT RELAY CHARACTERISTIC — For systems requiring other than very-inverse Type IFC53 time-overcurrent relays for phase relays (50/51) and residually connected ground relays (51N), substitute relays with the desired characteristic from page 7-2. For systems requiring time-delay ground sensors (51GS), substitute Type IFC53 relays for Type HFC relays.

OVERCURRENT RELAY QUANTITY — For feeders including ground-sensor, ground-overcurrent protection and for which the minimum protection is acceptable, omit one phase-overcurrent relay (50/51) from phase 2, and omit the associated current transformer. For feeders including residual ground overcurrent protection, omit one phase overcurrent relay (50/51) from phase 2.

AUTOMATIC RECLOSING — For open-wire overhead distribution circuits on which this feature is desired, add Type NLR automatic-reclosing relay (79) and cutoff switch (79CO).

Current Transformers for Remotely Located Differential Relays

For a feeder included in a bus-differential-protected zone, add a separate set of three current transformers located on the outgoing side of the feeder circuit breaker. For a feeder included in a transformer-differential-protected zone, add a separate set of three current transformers located on the bus side of the feeder circuit breaker.

Indication

INSTRUMENTATION AND METERING — For circuits requiring the indication or metering of

additional electrical quantities, add indicating volt-meter plus transfer switch, watt-hour meter or watt-hour demand meter, as appropriate. For continuous indication of current, substitute three ammeters instead of an ammeter and switch.

TEST BLOCKS — For circuits which require the provision for insertion of portable recording meters or other similar devices, add current and potential test blocks. The basic current test block is wired to maintain the circuit when the test plug is removed.

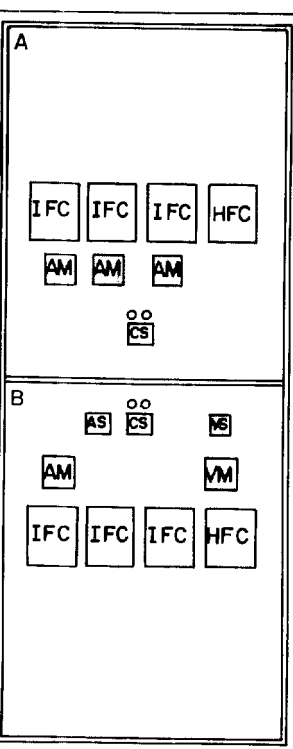
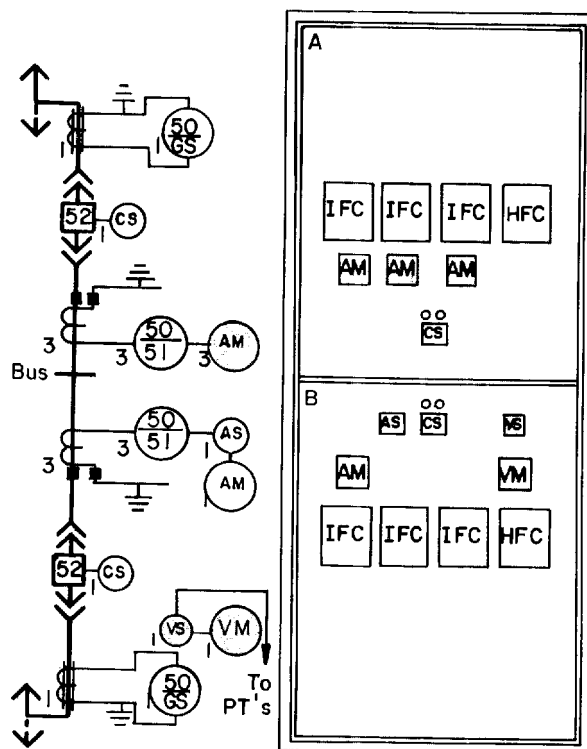
INDICATING LAMP — For circuits requiring a circuit-breaker disagreement or spring-charged indication function, add a white indicating lamp.

Control

CONTROL VOLTAGE — For equipments other than those with circuit-breaker control from a 125-volt dc station battery, substitute the appropriate available control voltage. For ac control, include a control power transformer connected to the incoming line in each lineup, plus an auto-charged, capacitor-trip device for each circuit breaker in the lineup.

REMOTE CONTROL — For circuit breakers controlled from a remote location, choose the remote control scheme from those listed in Table 5-1 (page 5-7 of this guide.) Scheme C is recommended, since it provides maximum operating flexibility. It requires the use of a breaker position switch in conjunction with the breaker control switch to provide the permissive function. With Scheme C, remote close and trip is possible only with the breaker in the "connected" position; local close with the breaker in the "test" position; and local trip with the breaker in the "connected" or "test" position.

TYPICAL MODIFICATIONS OF GPF-1



DEVICE LIST (Unit A)

All GPF-1 Devices

OMIT:

One SB-1 Ammeter Switch

ADD:

Two AB-40 Ammeters

DEVICE LIST (Unit B)

All GPF-1 Devices

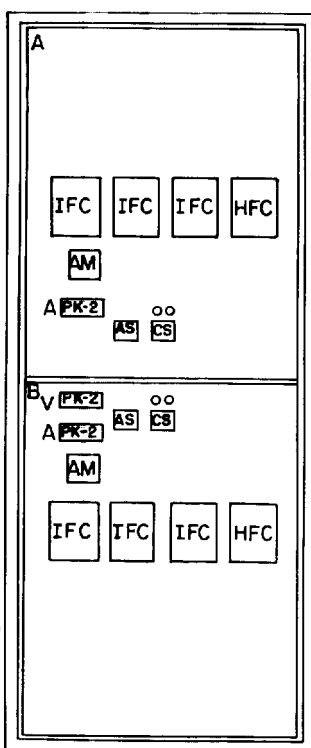
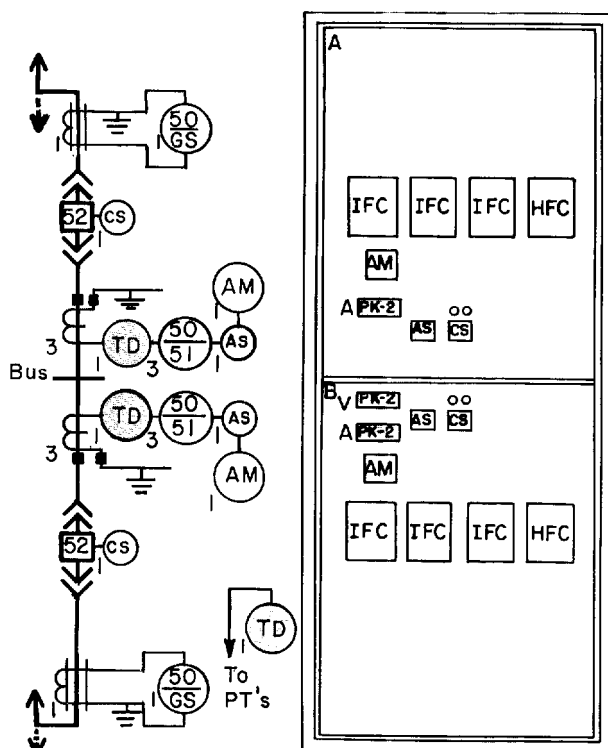
OMIT: None.

ADD:

One AB-40 Voltmeter

One SB-1 Voltmeter Switch

TYPICAL MODIFICATIONS OF GPF-1



DEVICE LIST (Unit A)

All GPF-1 Devices

OMIT: None.

ADD:

One PK-2 Current Test Block

DEVICE LIST (Unit B)

All GPF-1 Devices

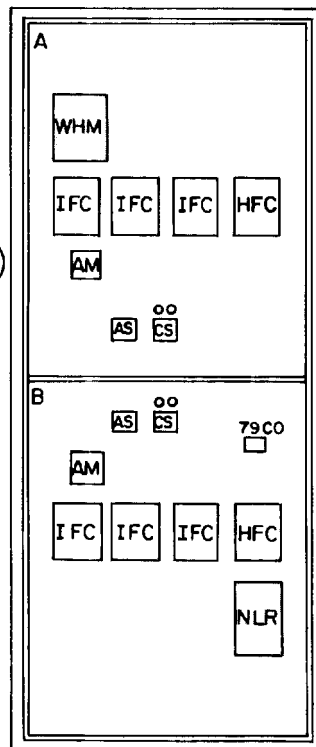
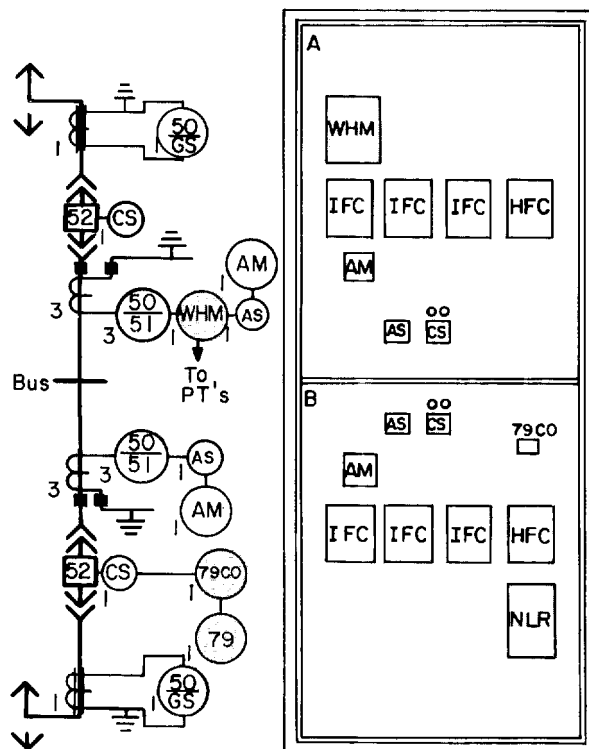
OMIT: None.

ADD:

One PK-2 Voltage Test Block

One PK-2 Current Test Block

TYPICAL MODIFICATIONS OF GPF-1

DEVICE LIST
(Unit A)

All GPF-1 Devices

OMIT: None

ADD:

One DS-63 Watthour Meter

DEVICE LIST
(Unit B)

All GPF-1 Devices

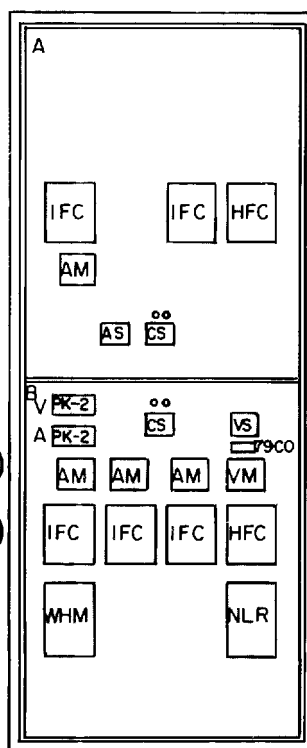
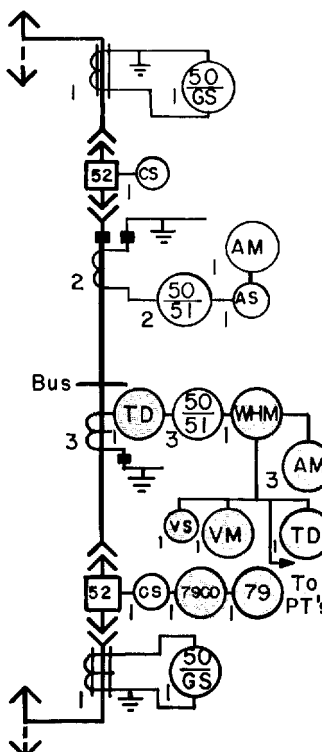
OMIT: None

ADD:

One NLR21 Reclosing Relay

One JBT Reclosing Cut-off Switch

TYPICAL MODIFICATIONS OF GPF-1

DEVICE LIST
(Unit A)

All GPF-1 Devices

OMIT:

One IFC Phase Overcurrent Relay
One Current Transformer

ADD: None

DEVICE LIST
(Unit B)

GPF-1 Devices

(Maximum optional devices)

OMIT:

One SB-1 Ammeter Switch

ADD:

Two AB-40 Ammeters

One AB-40 Voltmeter

One SB-1 Voltmeter Switch

One PK-2 Voltage Test Block

One PK-2 Current Test Block

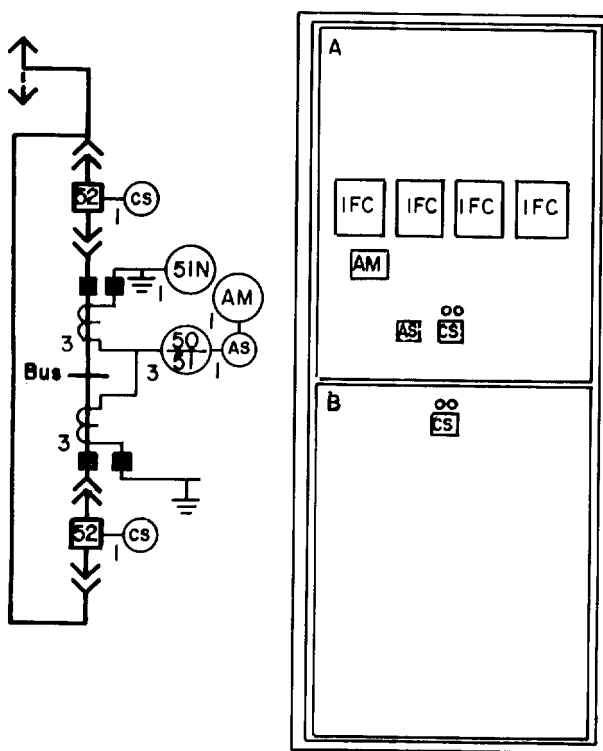
One DS-63 Watthour Meter

One NLR21 Reclosing Relay

One JBT Reclosing Cut-off Switch

Section 6

BREAKER BYPASS FEEDER (BBF-2)

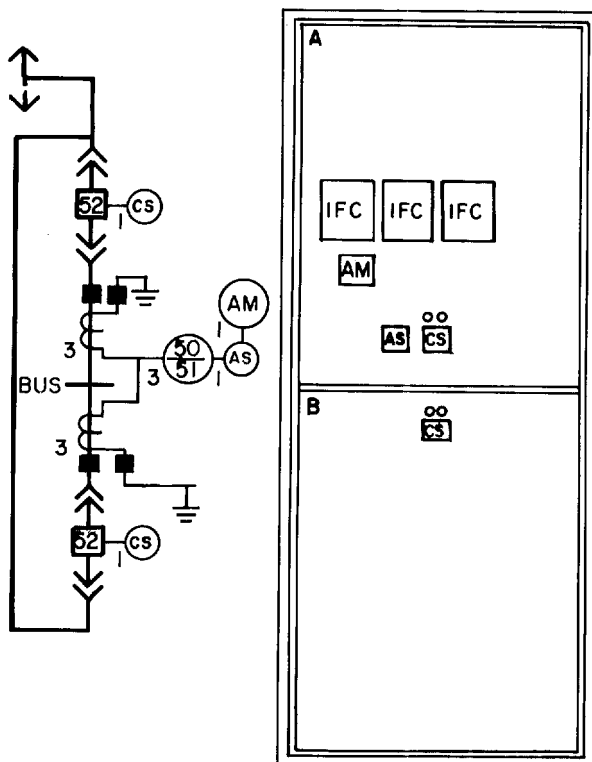


DEVICE LIST FOR BBF-2 (Unit A AND Unit B)

Device	Device No. or Abbr.	Qty	Description or Model No.
Power Circuit Breaker†	52	1	VB - (kV) (MVA) (A)
Phase Overcurrent Relays	50/51	3	12IFC53B1A
Residual Overcurrent Relay	51N	1	12IFC53A2A
Current Transformers	CT	6	JAG-0 (___/5A)
Breaker Control Switch	CS	2	16SB1B9X2
Indicating Lights	IL	4	ET-16, 125V (2-R,2-G)
Breaker Closing Fuse Pullout	FU	1	2P-30A (15A Fuses)
Breaker Tripping Fuse Pullout	FU	1	2P-60A (35A Fuses)
Ammeter (Scale to Match CT)	AM	1	AB-40
Ammeter Switch	AS	1	16SB1CA15X2
Provision for Power Conductor Terminations (NEMA Drilling Only)	—	2	Per phase

† For bypass operation, one additional breaker is required per lineup

BREAKER BYPASS FEEDER (BBF-3)



DEVICE LIST FOR BBF-3 (Unit A AND Unit B)

Device	Device No. or Abbr.	Qty	Description or Model No.
Power Circuit Breaker†	52	1	VB - (kV) (MVA) (A)
Phase Overcurrent Relays	50/51	3	12IFC53B1A
Current Transformers	CT	6	JAG-0 (___/5A)
Breaker Control Switch	CS	2	16SB1B9X2
Indicating Lights	IL	4	ET-16, 125V (2-R,2-G)
Breaker Closing Fuse Pullout	FU	1	2P-30A (15A Fuses)
Breaker Tripping Fuse Pullout	FU	1	2P-60A (35 Fuses)
Ammeter (Scale to Match CT)	AM	1	AB-40
Ammeter Switch	AS	1	16SB1CA15X2
Provisions for Power Conductor Terminations (NEMA Drilling Only)	—	2	Per phase

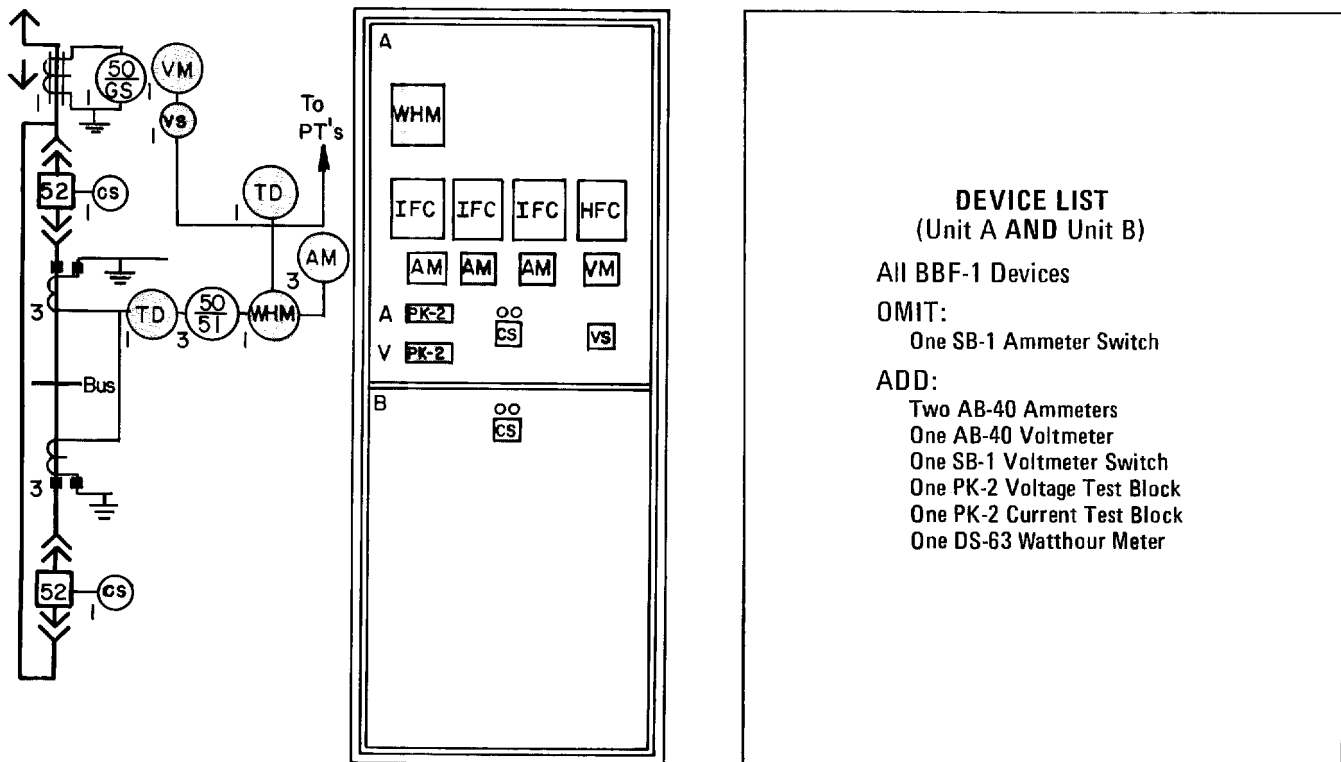
† For bypass operation, one additional breaker is required per lineup

POWER/VAC Switchgear Equipment

OPTIONAL EQUIPMENT SELECTION

Basic options for a breaker bypass feeder are the same as for a general purpose feeder. Select options for BBF-1, BBF-2, or BBF-3 on the same basis as for GPF-1, GPF-2, or GPF-3.

TYPICAL MODIFICATIONS OF BBF-1



TRANSFORMER PRIMARY FEEDERS

DEFINITION

A transformer primary feeder equipment (TPF) with differential relays Type STD (87T), is similar to a general purpose feeder except the entire load is one transformer, and the circuit is protected with transformer differential relays. Only the Unit A location should be selected because of the need to locate the transformer relays conveniently.

If transformer differential protection is not required, use a General Purpose Feeder.

BASIC EQUIPMENT SELECTION

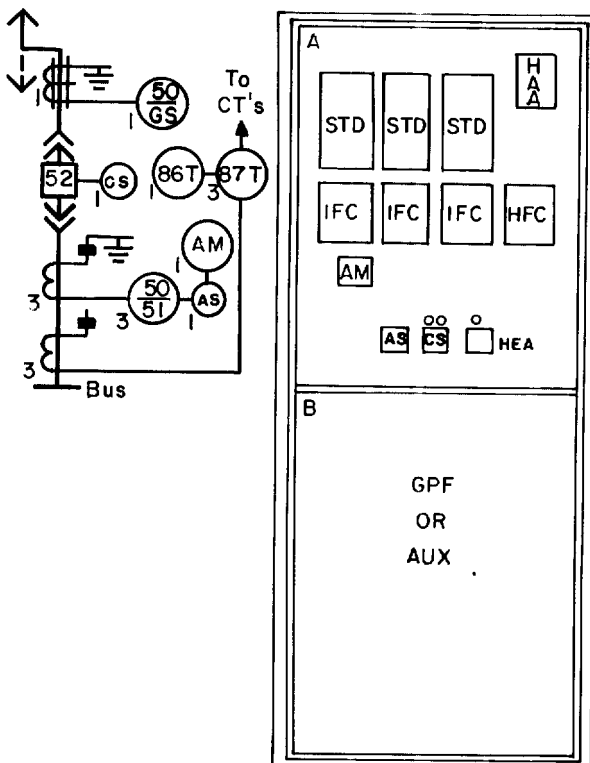
Basic devices included in a transformer primary feeder are the same as those included in a general

purpose feeder plus three current transformers, three Type STD high-speed transformer-differential relays (87T), one Type HEA hand-reset lockout relay (86T), and one Type HAA transformer fault-pressure auxiliary relay (63FPX). Select TPF-1, TPF-2, or TPF-3 on the same basis as GPF-1, GPF-2, and GPF-3.

OPTIONAL EQUIPMENT SELECTION

Basic options for a transformer primary feeder are the same as for a general purpose feeder except that automatic reclosing is not used. Select options for TPF-1, TPF-2, or TPF-3 on the same basis as for GPF-1, GPF-2, or GPF-3.

TRANSFORMER PRIMARY FEEDER (TPF-1)

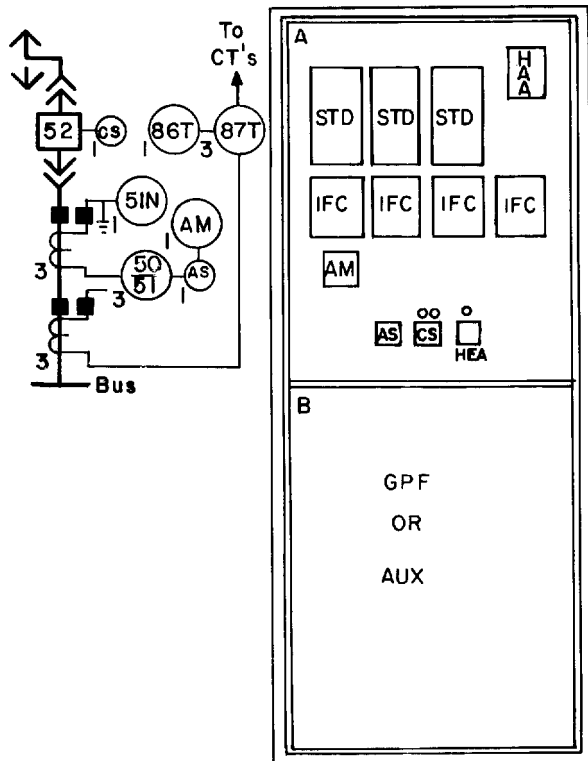


DEVICE LIST FOR TPF-1 (Unit A only)

Device	Device No. or Abbr.	Qty	Description or Model No.
Power Circuit Breaker	52	1	VB - (kV) (MVA) (A)
Phase Overcurrent Relays	50/51	3	12IFC53B1A
Ground Sensor Relay	50GS	1	12HFC11B1A
Transformer Differential Relays	87T	3	12STD15C5A
Lockout Relay	86T	1	12HEA61B237
Fault Pressure Auxiliary Relay	63FPX	1	12HAA16B2
Circuit Current Transformers	CT	3	JAG-0 (___/5A)
Differential Current Transformers	CT	3	JAG-0 (___/5A)
Ground Sensor Current Transformer	CT	1	Tech-Tran G.S.
Breaker Control Switch	CS	1	16SB1B9X2
Indicating Lights	IL	3	ET-16, 125V (1-R,1-G,1-W)
Breaker Closing Fuse Pullout	FU	1	2P-30A (15A Fuses)
Breaker Tripping & L.O. Fuse Pullouts	FU	2	2P-60A (35A Fuses)
Ammeter (Scale to Match CT)	AM	1	AB-40
Ammeter Switch	AS	1	16SB1CA15X2
Provision for Power Conductor Terminations (NEMA Drilling Only)	---	2	Per phase

POWER/VAC Switchgear Equipment

TRANSFORMER PRIMARY FEEDER (TPF-2)

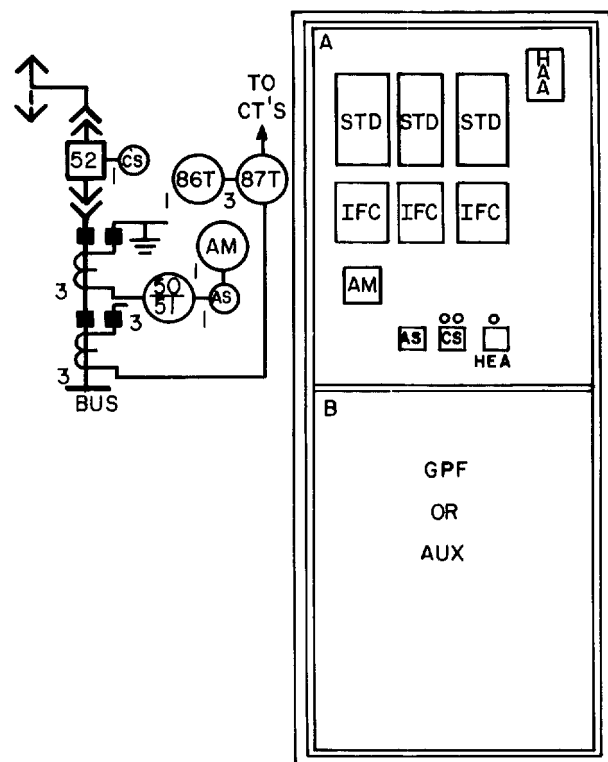


DEVICE LIST FOR TPF-2

(Unit A only)

Device	Device No. or Abbr.	Qty	Description or Model No.
Power Circuit Breaker	52	1	VB - (kV) (MVA) (A)
Phase Overcurrent Relays	50/51	3	12IFC53B1A
Residual Overcurrent Relay	51N	1	12IFC53A2A
Transformer Differential Relays	87T	3	12STD15C5A
Lockout Relay	86T	1	12HEA61B237
Fault Pressure Auxiliary Relay	63FPX	1	12HAA16B2
Circuit Current Transformers	CT	3	JAG-0 (/5A)
Differential Current Transformers	CT	3	JAG-0 (/5A)
Breaker Control Switch	CS	1	16SB1B9X2
Indicating Lights	IL	3	ET-16, 125V (1-R,1-G,1-W)
Breaker Closing Fuse Pullout	FU	1	2P-30A (15A Fuses)
Breaker Tripping & L.O. Fuse Pullouts	FU	2	2P-60A (35A Fuses)
Ammeter (Scale to Match CT)	AM	1	AB-40
Ammeter Switch	AS	1	16SB1CA15X2
Provision for Power Conductor Terminations (NEMA Drilling Only)	—	2	Per phase

TRANSFORMER PRIMARY FEEDER (TPF-3)



DEVICE LIST FOR TPF-3

(Unit A only)

Device	Device No. or Abbr.	Qty	Description or Model No.
Power Circuit Breaker	52	1	VB - (kV) (MVA) (A)
Phase Overcurrent Relays	50/51	3	12IFC53B3A
Transformer Differential Relays	87T	3	12STD15C5A
Lockout Relay	86T	1	12HEA61B237
Fault Pressure Auxiliary Relay	63FPX	1	12HAA16B2
Circuit Current Transformers	CT	3	JAG-0 (/5A)
Differential Current Transformers	CT	3	JAG-0 (/5A)
Breaker Control Switch	CS	1	16SB1B9X2
Indicating Lights	IL	3	ET-16, 125V (1-R,1-G,1-W)
Breaker Closing Fuse Pullout	FU	1	2P-30A (15A Fuses)
Breaker Tripping & L.O. Fuse Pullouts	FU	2	2P-60A (35A Fuses)
Ammeter (Scale to Match CT)	AM	1	AB-40
Ammeter Switch	AS	1	16SB1CA15X2
Provision for Power Conductor Terminations (NEMA Drilling Only)	—	2	Per phase

SINGLE SOURCE INCOMING LINES (or dual source with normally open tie breakers)

DEFINITION

A single source incoming line equipment (SSIL) is a metalclad equipment for a circuit to a main power distribution bus from the only source of power supplying the bus.

A system with two or more incoming lines which supply distribution buses sectionalized by normally open bus-tie breakers, requires essentially the same type of protection, instrumentation, and control for each incoming line as a single source incoming line.

BASIC EQUIPMENT SELECTION

SSIL-1 Use this type of incoming line for an impedance or solidly grounded system fed from a local wye-connected transformer with a current transformer in the transformer neutral connection.

This type of incoming line equipment includes three Type IFC phase-overcurrent

relays (51) and one Type IFC ground-over-current relay (51G) to be connected to the neutral current transformer of a local power transformer feeding the incoming line.

SSIL-2 Use this type of incoming line for an impedance or solidly grounded system fed from a remote wye-connected transformer, or a local wye-connected transformer with no current transformer in the transformer neutral connection.

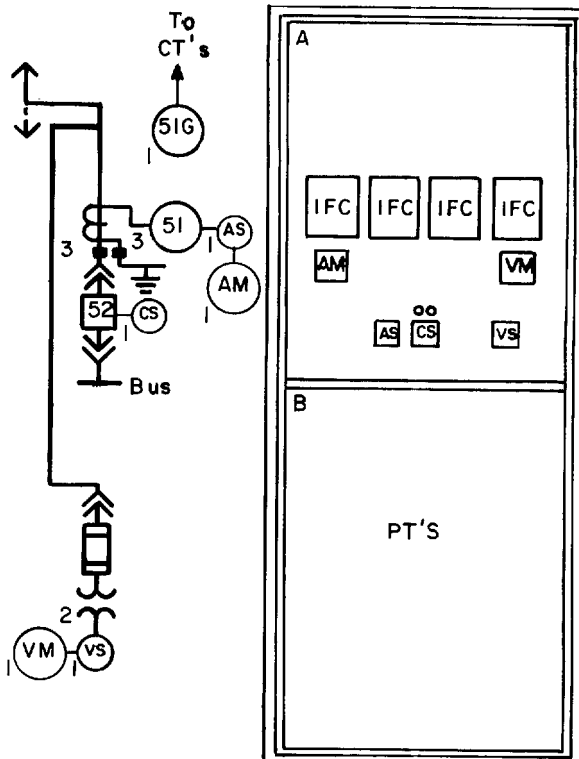
This type of incoming line equipment includes three Type IFC phase-overcurrent relays (51) and Type IFC residually connected ground-overcurrent relay (51N).

SSIL-3 Use this type of incoming line for ungrounded or solidly grounded systems for which no ground relays are desired.

This type of incoming line equipment includes three Type IFC phase-overcurrent relays (51) and no ground relays.

SINGLE SOURCE INCOMING LINES (SSIL-1)

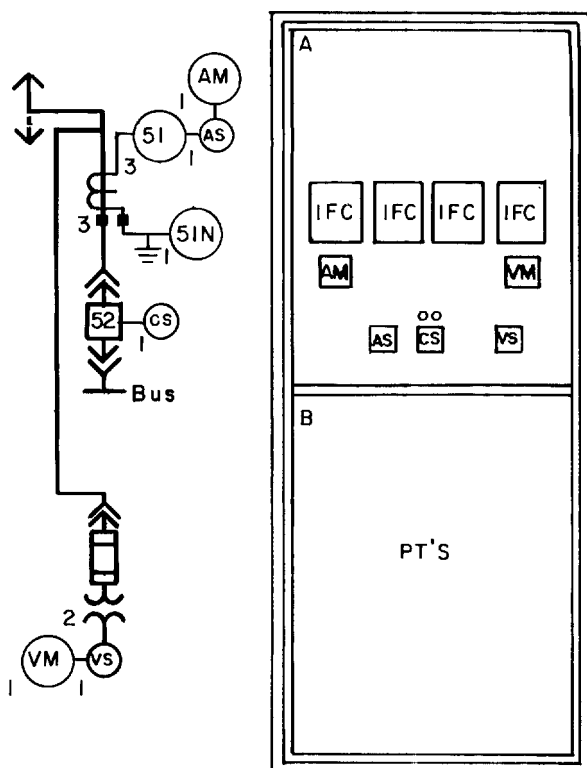
NOTE: For 3000A breaker, locate breaker in Unit B and potential transformers in Unit A.



DEVICE LIST FOR SSIL-1 (Unit A AND Unit B)

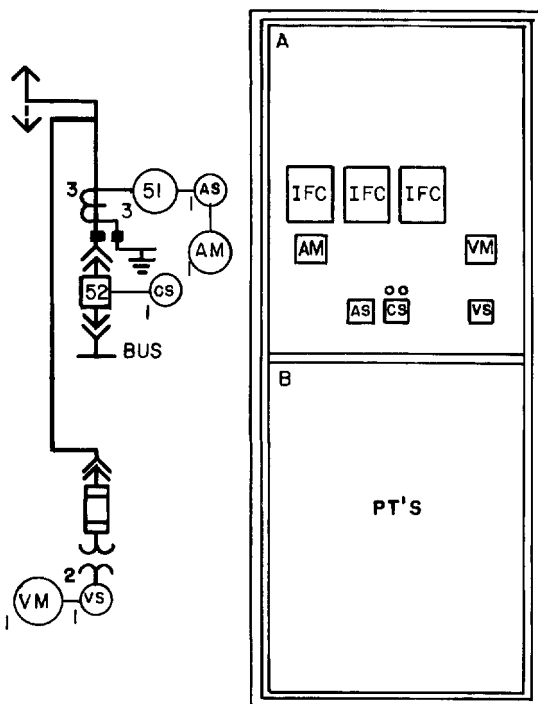
Device	Device No. or Abbr.	Qty	Description or Model No.
Power Circuit Breaker	52	1	VB - (kV) (MVA) (A)
Phase Overcurrent Relays	51	3	12IFC53A1A
Ground Overcurrent Relay	51G	1	12IFC53A2A
Current Transformers	CT	3	JAG-0 (/5A)
Potential Transformers	PT	2	JVM (/120V)
Breaker Control Switch	CS	1	16SB1B9X2
Indicating Lights	IL	2	ET-16, 125V (1-R,1-G)
Breaker Closing Fuse Pullout	FU	1	2P-30A (15A Fuses)
Breaker Tripping Fuse Pullout	FU	1	2P-60A (35A Fuses)
PT Fuses	FU-PT	4	2E
Ammeter (Scale to Match CT)	AM	1	AB-40
Voltmeter (Scale to Match PT)	VM	1	AB-40
Ammeter Switch	AS	1	16SB1CA15X2
Voltmeter Switch	VS	1	16SB1CF11X2
Provision for Power Conductor Terminations (NEMA Drilling Only)	---	2	Per phase

NOTE: For 3000A breaker, locate breaker in Unit B and potential transformers in Unit A.



Device	Device No. or Abbr.	Qty	Description or Model No.
Power Circuit Breaker	52	1	VB - <u> </u> - <u> </u> - <u> </u> (kV) (MVA) (A)
Phase Overcurrent Relays	51	3	121FC53A1A
Residual Overcurrent Relay	51N	1	121FC53A2A
Current Transformers	CT	3	JAG-0 (<u> </u> /5A)
Potential Transformers	PT	2	JVM (<u> </u> /120V)
Breaker Control Switch	CS	1	16SB1B9X2
Indicating Lights	IL	2	ET-16, 125V (1-R,1-G)
Breaker Closing Fuse Pullout	FU	1	2P-30A (15A Fuses)
Breaker Tripping Fuse Pullout	FU	1	2P-60A (35A Fuses)
PT Fuses	FU-PT	4	2E
Ammeter (Scale to Match CT)	AM	1	AB-40
Voltmeter (Scale to Match PT)	VM	1	2E
Ammeter Switch	AS	1	16SB1CA15X2
Voltmeter Switch	VS	1	16SB1CF11X2
Provision for Power Conductor Terminations (NEMA Drilling Only)	—	2	Per phase

NOTE: For 3000A breaker, locate breaker in Unit B and potential transformers in Unit A.



Device	Device No. or Abbr.	Qty	Description or Model No.
Power Circuit Breaker	52	1	VB - (kV) - (MVA) - (A)
Phase Overcurrent Relays	51	3	121FC53A1A
Current Transformers	CT	3	JAG-0 (___/5A)
Potential Transformers	PT	2	JVM (___/120V)
Breaker Control Switch	CS	1	16SB1B9X2
Indicating Lights	IL	2	ET-16, 125V (1-R, 1-G)
Breaker Closing Fuse Pullout	FU	1	2P-30A (15A Fuses)
Breaker Tripping Fuse Pullout	FU	1	2P-60A (35A Fuses)
PT Fuses	FU-PT	4	2E
Ammeter (Scale to Match CT)	AM	1	AB-40
Voltmeter (Scale to Match PT)	VM	1	AB-40
Ammeter Switch	AS	1	16SB1CA15X2
Voltmeter Switch	VS	1	16SB1CF11X2
Provision for Power Conductor Terminations (NEMA Drilling Only)	---	2	Per phase

Single Source Incoming Lines

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OPTIONAL EQUIPMENT SELECTION**Protection**

OVERCURRENT RELAY CHARACTERISTIC — For systems requiring other than very-inverse Type IFC53 time-overcurrent relays for phase relays (50/51) and residually connected ground relays (51N), substitute relays with the desired characteristics from page 7-2.

OVERCURRENT RELAY QUANTITY — For incoming lines including ground-overcurrent protection and for which the minimum protection is acceptable, omit one phase overcurrent relay (51) from phase 2, and omit the associated current transformer.

CURRENT SUMMATION CONNECTION — For lineups containing normally open bus-tie breakers, specify the incoming line overcurrent relays to be wired for current summation. Add a lockout relay (86) and a set of three tie breaker CT's added for each set of relays to be wired this way.

OPEN-PHASE PROTECTION — For incoming lines fed from transformers with fused primaries or sources subject to single-phase operation, add a negative-sequence voltage relay Type NBV (60) and a timer (62). If the system is subject to harmonics, specify a harmonic filter for the Type NBV relay.

TRANSFORMER DIFFERENTIAL PROTECTION — For incoming lines fed from transformers with a means to trip a primary breaker and for which differential protection is desired, add three Type STD transformer differential relays (87T), one Type HEA lockout relay (86T), one Type HAA fault pressure auxiliary relay (63FPX), and a set of three current transformers. For impedance grounded systems with larger transformers and for which transformer differential relaying is not sensitive enough to detect secondary ground faults, add a Type IFD ground differential relay (87TG) and an auxiliary current transformer.

BUS DIFFERENTIAL PROTECTION — For systems requiring bus differential protection, add

three Type PVD high-speed bus differential relays (87B) and one Type HEA hand reset lockout relay (86B).

CURRENT TRANSFORMERS FOR REMOTELY LOCATED DIFFERENTIAL RELAYS — For incoming lines included in bus or transformer differential zones for which relays are not mounted on the incoming line equipment, add a separate set of three current transformers for each differential function.

DIRECTIONAL POWER, UNDERFREQUENCY, AND UNDERVOLTAGE PROTECTION — To detect utility tie circuit fault conditions prior to automatic reclosing and to initiate programmed load shedding, add, either singly or in combination, Type CCP directional relay (32), Type SFF underfrequency relay (81), undervoltage relay (27) and timer (62). This applies for systems with local generation or large motors. A study of each system is required to assure proper selection and circuit location of these relays.

AUTOMATIC THROWOVER — For lineups with a normally open tie breaker or a normally open alternate incoming line breaker, add automatic throwover equipment if desired. This consists of two Type NGV undervoltage relays (27), two Type HFA auxiliary relays (27X), two timers (2 and 62), two Type HGA auxiliary relays (2X and 62X), and one Type SB-1 manual-automatic switch (43). Automatic throwover equipment requires an additional auxiliary compartment, custom designed for each application.

Indication

INSTRUMENTATION AND METERING — For incoming lines for which voltage indication and a relay potential source are not required, omit the voltmeter, voltmeter switch, and two potential transformers. For circuits requiring the indication or metering of additional electrical quantities, add indicating varmeter, wattmeter, watthour meter, or watthour demand meter as appropriate. For simultaneous continuous indication of all three phases of current, substitute three ammeters for an ammeter and switch.

TEST BLOCKS — For circuits which require the provision for insertion of portable recording meters

Single Source
Incoming Lines

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or other similar devices, add current and potential test blocks. The basic current test block is wired to maintain the circuit when the test plug is removed.

INDICATING LAMP — For circuits requiring a circuit breaker disagreement or spring-charged indication function, add a white indicating lamp.

Control

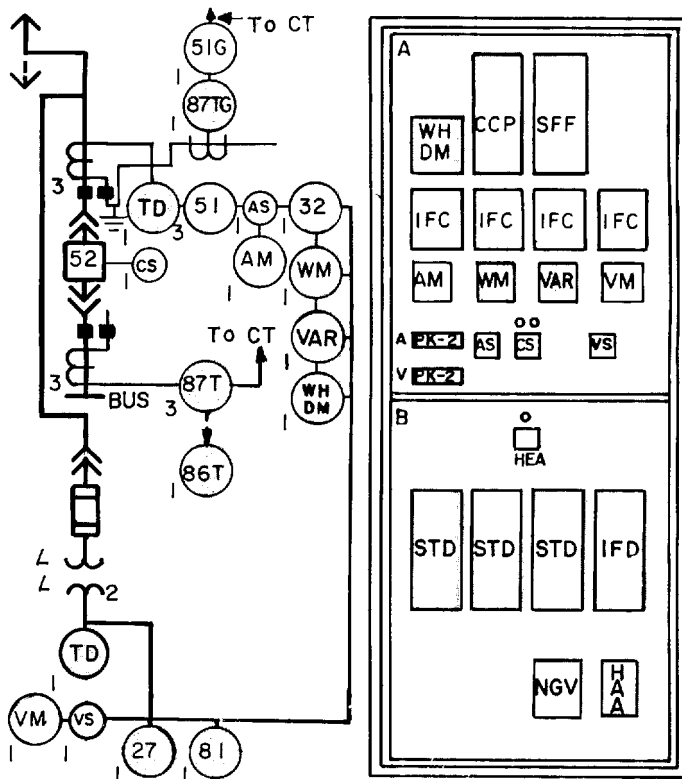
CONTROL VOLTAGE — For equipments other than those with circuit breaker control from a 125-volt dc station battery, substitute the appropriate available control voltage. For ac control, include a control power transformer connected to the incoming line in each line-up bus, plus an auto-charged capacitor trip device for each circuit breaker in the lineup; omit Type STD relays (87T) and add Type BDD relays (87T). For dual source with normally open-tie circuit breaker and ac control, add secondary throwover contactor.

REMOTE CONTROL — For circuit breakers controlled from a remote location, choose the remote control scheme from those listed in Table 5-1 (page 5-7 of this guide.) Scheme C is recommended, since it provides maximum operating flexibility. It requires the use of a breaker position switch in conjunction with the breaker control switch to provide the permissive function. With Scheme C, remote close and trip is possible only with the breaker in the "connected" position; local close with the breaker in the "test" position; and local trip with the breaker in the "connected" or "test" position.

Location of Optional Devices

If several optional devices are added to an incoming line equipment, there may not be sufficient space to mount them all. In this case, specify excess relays to be mounted on the tie breaker vertical sections or an adjacent auxiliary compartment. This makes the vertical section a custom section.

TYPICAL MODIFICATIONS OF SSIL-1



DEVICE LIST

(Unit A AND Unit B)

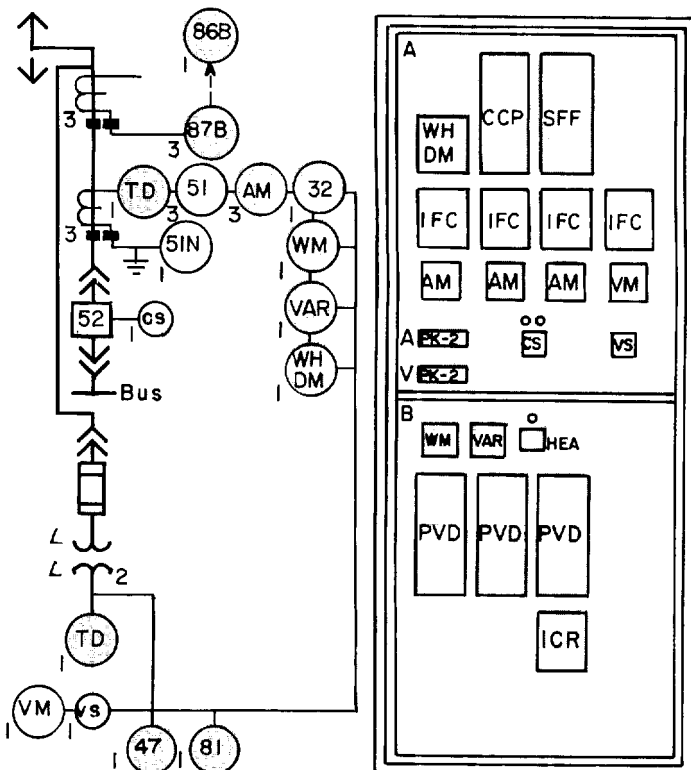
All SSIL-1 Devices

OMIT: None

ADD:

- Three STD15 Transformer Differential Relays
- One IFD51 Transformer Ground Differential Relay
- One HEA61 Lockout Relay
- One HAA16 Transformer Fault Pressure Auxiliary Relay
- One CCP13 Directional Power Relay
- One SFF23 Frequency Relay
- One NGV13 Undervoltage
- One DSM63 Watthour Demand Meter
- One AB-40 Wattmeter
- One PK-2 Voltage Test Block
- One PK-2 Current Test Block

TYPICAL MODIFICATIONS OF SSIL-2



DEVICE LIST

(Unit A AND Unit B)

All SSIL-2 Devices

OMIT:

- One Ammeter Switch

ADD:

- Two AB-40 Ammeters
- Three PVD11 Bus Differential Relays
- One HEA61 Lockout Relay
- One CCP13 Directional Power Relay
- One SFF23 Frequency Relay
- One ICR53 Undervoltage and Phase Sequence Relay
- One DSM63 Watthour Demand Meter
- One AB-40 Wattmeter
- One PK-2 Voltage Test Block
- One PK-2 Current Test Block

POWER/VAC Switchgear Equipment

DUAL SOURCE INCOMING LINES

DEFINITION

Dual source incoming line equipment (DSIL) is metalclad equipment for a circuit to a main power distribution bus from one of two sources of power supplying the main bus. The other source of power may be either another incoming line or a local generator. Both sources supply a common distribution bus, with or without a normally closed bus-tie breaker.

BASIC EQUIPMENT SELECTION

DSIL-1 Use this type of incoming line for an impedance or solidly grounded system fed from a local wye-connected power transformer, with a current transformer in the transformer neutral connection.

This type of incoming line equipment includes three Type IFC phase-overcurrent relays (51) and three Type JBC directional phase-overcurrent relays (67). It includes one Type IFC ground-overcurrent relay, (51G) connected to the neutral CT of a local power transformer feeding the incoming line and one residually connected Type IBCG directional

ground-overcurrent relay (67N), polarized from the power transformer neutral CT.

DSIL-2 Use this type of incoming line for an impedance or solidly grounded system fed from a remote wye-connected power transformer.

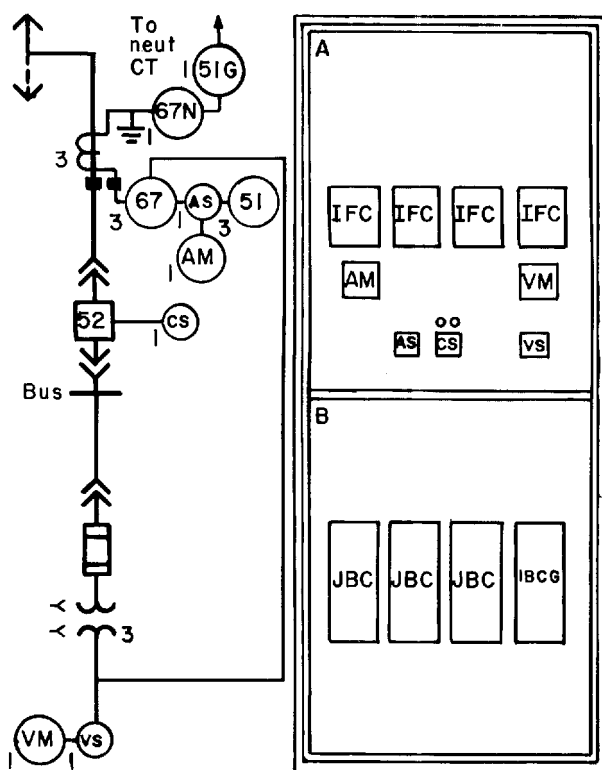
This type of incoming line equipment includes three Type IFC phase-overcurrent relays (51) and three Type IBC directional phase-overcurrent relays (67). It includes one Type IFC residual connected ground-overcurrent relay (51G) and one residually connected directional ground-overcurrent relay (67N) polarized from a wye-broken delta auxiliary PT connected to a set of wye-wye PT's.

DSIL-3 Use this type of incoming line for ungrounded systems only.

This type of incoming line equipment includes three Type IFC phase-overcurrent relays (51) and three Type IBC directional phase-overcurrent relays (67). There are no ground relays included.

DUAL SOURCE INCOMING LINES (DSIL-1)

NOTE: For 3000A breakers, locate breaker in Unit B and potential transformers in Unit A.



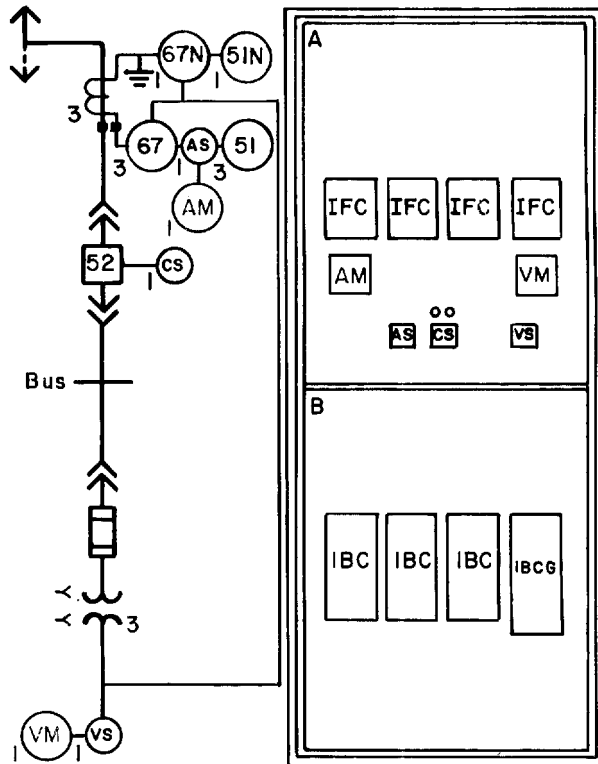
DEVICE LIST FOR DSIL-1 (Unit A AND Unit B)

Local or remote transformers –
No tie or normally closed tie.

Device	Device No. or Abbr.	Qty	Description or Model No.
Power Circuit Breaker	52	1	VB (kV) (MVA) (A)
Directional Phase Overcurrent Relays	67	3	12JBC53K4A
Directional Ground Overcurrent Relay	67N	1	12IBC653K3A
Phase Overcurrent Relay	51	3	12KFC53A1A
Ground Overcurrent Relay	51G	1	12IFC53A2A
Current Transformers	CT	3	JAG-0 (/5A)
Potential Transformers	PT	3	JVM (/120V)
Breaker Control Switch	CS	1	16SB189X2
Indicating Lights	IL	2	ET-16, 125V (1-R, 1-G)
Breaker Closing			
Fuse Pullout	FU	1	2P-30A (15A Fuses)
Breaker Tripping			
Fuse Pullout	FU	1	2P-60A (35A Fuses)
PT Fuses	FU-PT	3	2E
Ammeter (Scale to Match CT)	AM	1	AB-40
Voltmeter (Scale to Match PT)	VM	1	AB-40
Ammeter Switch	AS	1	16SB1CA15X2
Voltmeter Switch	VS	1	16SB1CF11X2
Provision for Power Conductor Terminations (NEMA Drilling Only)	—	2	Per phase

DUAL SOURCE INCOMING LINES (DSIL-2)

NOTE: For 3000A breakers, locate breaker in Unit B and potential transformers in Unit A.

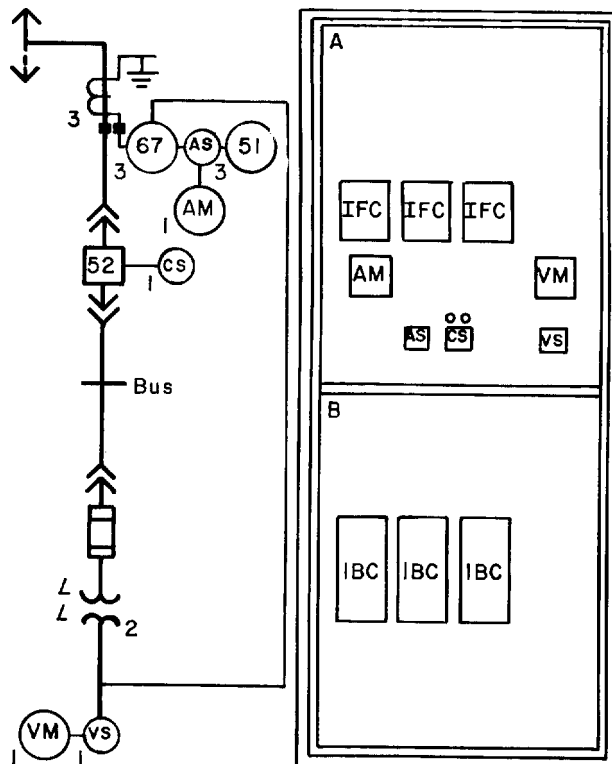
DEVICE LIST FOR DSIL-2
(Unit A AND Unit B)

Local or remote transformers –
No tie or normally closed tie.

Device	Device No. or Abbr.	Qty	Description or Model No.
Power Circuit Breaker	52	1	VB - (kV) (MVA) (A)
Directional Phase Overcurrent Relays	67	3	12IBC53K4A
Directional Ground Overcurrent Relay	67N	1	12IBC53K3A
Phase Overcurrent Relays	51	3	12IFC53A1A
Residual Overcurrent Relay	51N	1	12IFC53A2A
Current Transformers	CT	3	JAG-0 (___/5A)
Potential Transformers	PT	3	JVM (___/120V)
Auxiliary Potential Transformer	AUX-PT	1	9T56Y
Breaker Control Switch	CS	1	16SB189X2
Indicating Lights	IL	2	ET-16, 125V (1-R, 1-G)
Breaker Closing Fuse Pullout	FU	1	2P-30A (15A Fuses)
Breaker Tripping Fuse Pullout	FU	1	2P-60A (35A Fuses)
PT Fuses	FU-PT	3	2E
Ammeter (Scale to Match CT)	AM	1	AB-40
Voltmeter (Scale to Match PT)	VM	1	AB-40
Ammeter Switch	AS	1	16SB1CA15X2
Voltmeter Switch	VS	1	16SB1CF11X2
Provision for Power Conductor Terminations (NEMA Drilling Only)	---	2	Per phase

DUAL SOURCE INCOMING LINES (DSIL-3)

NOTE: For 3000A breakers, locate breaker in Unit B and potential transformers in Unit A.

DEVICE LIST FOR DSIL-3
(Unit A AND Unit B)

Local or remote transformers –
No tie or normally closed tie.

Device	Device No. or Abbr.	Qty	Description or Model No.
Power Circuit Breaker	52	1	VB - (kV) (MVA) (A)
Directional Phase Overcurrent Relays	67	3	12IBC53K4A
Phase Overcurrent Relays	51	3	12IFC53A1A
Current Transformers	CT	3	JAG-0 (___/5A)
Potential Transformers	PT	2	JVM (___/120V)
Breaker Control Switch	CS	1	16SB189X2
Indicating Lights	IL	2	ET-16, 125V (1-R 1-G)
Breaker Closing Fuse Pullout	FU	1	2P-30A (15A Fuses)
Breaker Tripping Fuse Pullout	FU	1	2P-60A (35A Fuses)
PT Fuses	FU-PT	4	2E
Ammeter (Scale to Match CT)	AM	1	AB-40
Voltmeter (Scale to Match PT)	VM	1	AB-40
Ammeter Switch	AS	1	16SB1CA15X2
Voltmeter Switch	VS	1	16SB1CF11X2
Provision for Power Conductor Terminations (NEMA Drilling Only)	---	2	Per phase

POWER/VAC Switchgear Equipment

OPTIONAL EQUIPMENT SELECTION

Protection

OVERCURRENT RELAY CHARACTERISTICS — For systems requiring other than very inverse Type IFC53, JBC53, or IBC53 time overcurrent relays, substitute relays with the desired characteristic from page 7-2.

OVERCURRENT RELAY QUANTITY — For incoming lines, including ground-overcurrent protection, and for which minimum protection is acceptable, omit one Type IAC phase-overcurrent relay (50/51) and one Type JBC directional phase-overcurrent relay (67) from phase 2. The phase 2 current transformer may not be omitted since it is necessary for the directional ground relay residual connection.

OPEN-PHASE PROTECTION — For incoming lines fed from transformers with fused primaries or sources subject to single-phase operation, add one negative-sequence voltage relay Type NBV (60) and timer (62), as well as three Type IJC current-balance relays (60C), to distinguish which incoming line has single-phase operation. If the system is subject to harmonics, specify a harmonic filter for the Type NBV relay.

TRANSFORMER AND BUS DIFFERENTIAL PROTECTION — Add relays and current transformers to obtain this protection, using the same considerations as for single source incoming lines.

DIRECTIONAL POWER, UNDERFREQUENCY, AND UNDERVOLTAGE PROTECTION — Add relays to obtain this protection, using the same considerations as for single source incoming lines.

Indication

INSTRUMENTATION AND METERING — For circuits requiring the indication or metering of additional electrical quantities, add indicating varmeter, wattmeter, watthour meter, or watthour demand meter as appropriate. For simultaneous continuous indication of all three phases of current, substitute three ammeters for an ammeter and switch.

TEST BLOCKS — For circuits which require the provision for insertion of portable recording meters or other similar devices, add current and potential test block. Basic test block is wired to maintain the circuit when the test plug is removed.

INDICATING LAMP — For circuits requiring a circuit breaker disagreement or spring-charged indication function, add a white indicating lamp.

Control

Optional feature involving control voltage and permissive control switch are the same as for single-source incoming line equipments.

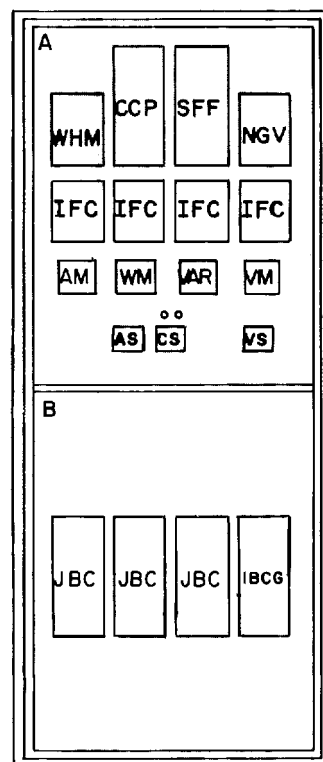
Location of Optional Devices

If several optional devices are added to an incoming line equipment, there may not be sufficient space to mount them all. In this case, specify excess relays to be mounted on the tie-breaker vertical section, or on an adjacent auxiliary compartment. This makes the vertical section a custom section.

Dual Source
Incoming Lines

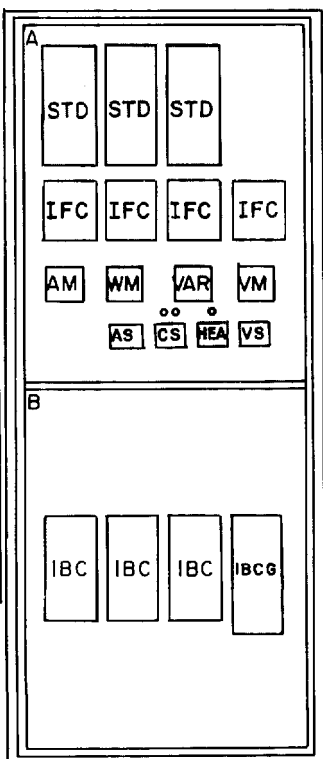
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Dual Source Incoming Lines



One CCP13 Directional Ground Relay
One SFF21 Frequency Relay
One NGV13 Undervoltage Relay
One DS63 Watthour Meter
One AB-40 Wattmeter
One AB-40 Varimeter
One Agastat Timer

9



Three STD15 Transformer Differential Relays
One HEA61 Lockout Relay
One AB-40 Wattmeter
One AB-40 Varmeter
Three Current Transformers

POWER/VAC Switchgear Equipment

BUS TIES

DEFINITION

A bus-tie is metalclad equipment connecting two power distribution buses with a tie breaker. Such equipment is specified frequently without overcurrent relays because of the difficulty of obtaining selective system operation when using bus-tie overcurrent relays.

BASIC EQUIPMENT SELECTION

Basic bus-tie equipment is located in the bottom compartment of each of two vertical sections. The top compartment of either or both vertical sections can be used as either an auxiliary compartment or a feeder compartment.

The basic equipment included in a bus-tie is a circuit breaker control switch and indicating lights.

OPTIONAL EQUIPMENT SELECTION

Protection

OVERCURRENT PROTECTION — For systems requiring overcurrent protection relays for bus-tie equipment, specify incoming line Type IFC overcurrent relays (51) to be wired for a summation current connection. If Type IFC residually connected ground-overcurrent relays (51N) are included with an incoming line, the equipment may be wired also for a summation current connection. Specify a second set of three current transformers for the second incoming line.

BUS-DIFFERENTIAL PROTECTION — For systems requiring bus-differential protection,

mount such equipment in bus-tie vertical sections. Each set of bus-differential protection includes three Type PVD high-speed bus-differential relays (87B), one Type HEA hand-reset lockout relay (86B), and three current transformers.

AUTOMATIC THROWOVER — For systems with a normally open bus-tie circuit breaker that require automatic throwover, add equipment listed under "Single Source Incoming Line Options" in a custom-designed auxiliary compartment above one of the bus-tie compartments.

Indication

INSTRUMENTATION — For indication of current, add three current transformers, an ammeter, and an ammeter switch. For simultaneous continuous indication of all three phases of current, substitute three ammeters for an ammeter and switch.

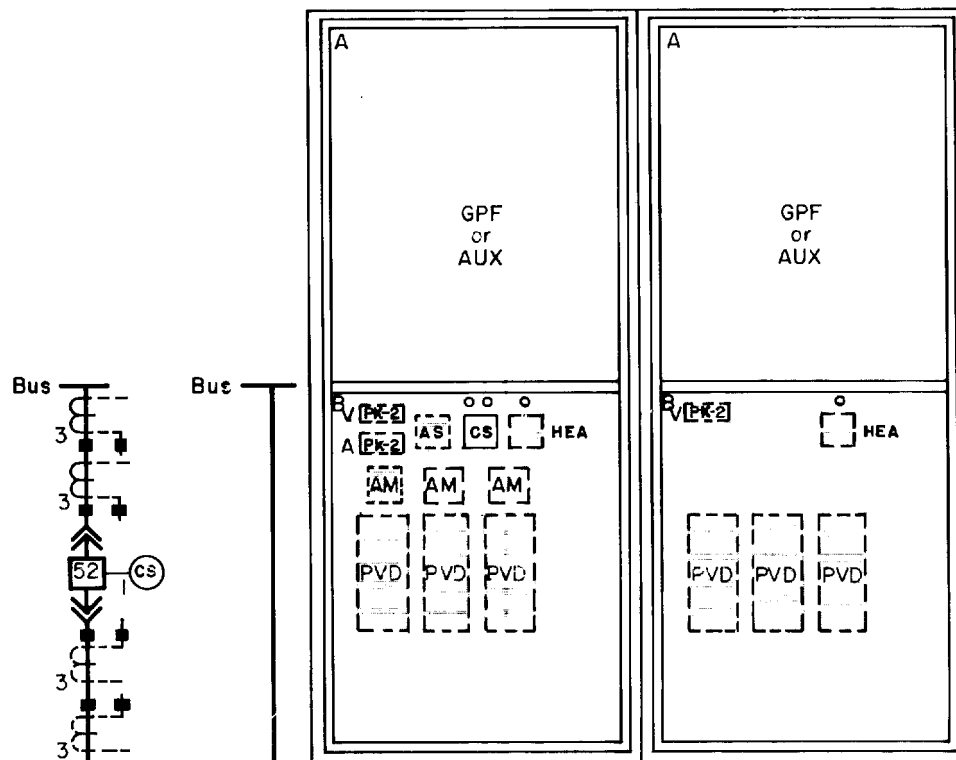
TEST BLOCKS — For circuits which require the provision for insertion of portable recording meters or other similar devices, add current and potential test blocks. Basic current test block is wired to maintain the circuit when the test plug is removed.

INDICATING LAMP -- A white indicating lamp is added to circuits requiring a circuit breaker disagreement or spring-charged indication function.

Control

Optional features involving control voltage and a permissive control switch are the same as for single source incoming line equipment. For circuit breakers where ac control is specified, include a secondary automatic-throwover contactor for control power.

BUS TIES (BT-1)



DEVICE LIST FOR BT (Unit B AND Unit B)

Device	Device No. or Abbr.	Qty	Description or Model No.
Power Circuit Breaker	52	1	VB - (kV) (MVA) (A)
Breaker Control Switch	CS	1	16SB1B9X2
Indicating Lights	IL	2	ET-16, 125V (1-R,1-G)
Breaker Closing Fuse Pullout	FU	1	2P-30A (15A Fuses)
Breaker Tripping Fuse Pullout	FU	1	2P-60A (35A Fuses)

POWER/VAC Switchgear Equipment

BUS ENTRANCES

DEFINITION

Bus-entrance equipment is a metalclad vertical section in which one of the compartments contains incoming conductors which connect directly to the main bus without the use of a circuit breaker.

BASIC EQUIPMENT SELECTION

The top compartment of a vertical section is used for basic bus-entrance equipment rated at 1200 amperes and 2000 amperes. The bottom compartment is used for equipment rated at 3000 amperes. Select this type of equipment as a means to connect either incoming or outgoing conductors directly to the bus for circuits that require no circuit breakers.

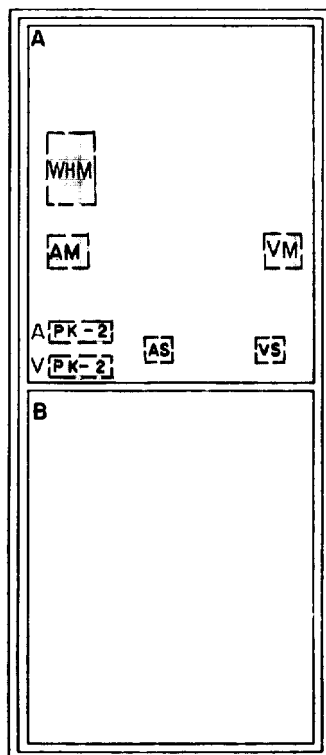
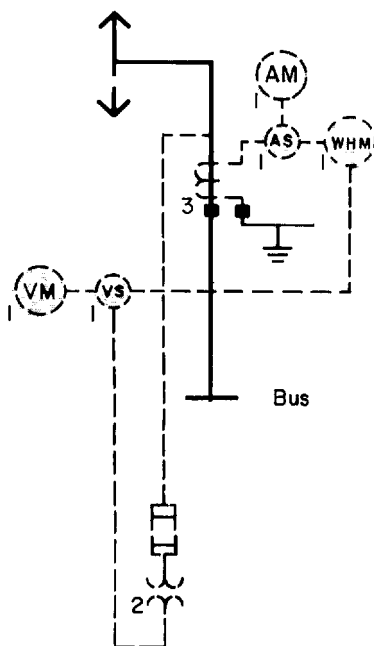
OPTIONAL EQUIPMENT SELECTION

Indication

INSTRUMENTATION AND METERING — For circuits requiring the indication or metering of electrical quantities, add two or three current transformers and two potential transformers. Arrangements are shown under "Power Conductor and Auxiliary Compartments" (pages 6-43 to 6-53). Select instrumentation and metering required from option tables in this section.

TEST BLOCKS — For circuits which require the provision for insertion of portable recording meters or other similar devices, add current and potential test blocks. Basic current block is wired to maintain the circuit when the test plug is removed.

BUS ENTRANCES (BE-1)



DEVICE LIST FOR BE (Unit A or Unit B)

Device	Device No. or Abbr.	Qty	Description or Model No.
Provisions for Power Conductor Terminations (NEMA Drilling Only)	—	2	Per phase

OPTIONS

OMIT: None

ADD:

- Three Current Transformers, JAG-0, (___/5A)
- One Ammeter, Type AB-40
- One Ammeter Switch, 16SB1CA15X2
- Two Potential Transformers, Type JVM, (___/120V)
- Four PT Fuses
- One Watthour Meter, Type DS-63, 2-element,
Secondary Reading, 701X90G1
- One Voltmeter, Type AB-40
- One Voltmeter Switch 16SB1CF11X2
- One PK-2 Current Test Block
- One PK-2 Voltage Test Block

INDUCTION MOTOR FEEDERS, FULL-VOLTAGE-START, ESSENTIAL SERVICE, ALL RATINGS

DEFINITION

These metalclad feeder equipments (IMFE) are used for controlling and protecting full-voltage-start, essential-service motors and are designated as motor "branch circuit" protective equipment. Such motor feeders sound an alarm only for motor overload, and trip the circuit breaker for locked rotor and short-circuit conditions.

BASIC EQUIPMENT SELECTION

IMFE basic equipment includes three single-phase Type IFC relays for overload indication, locked-rotor tripping, and short-circuit tripping

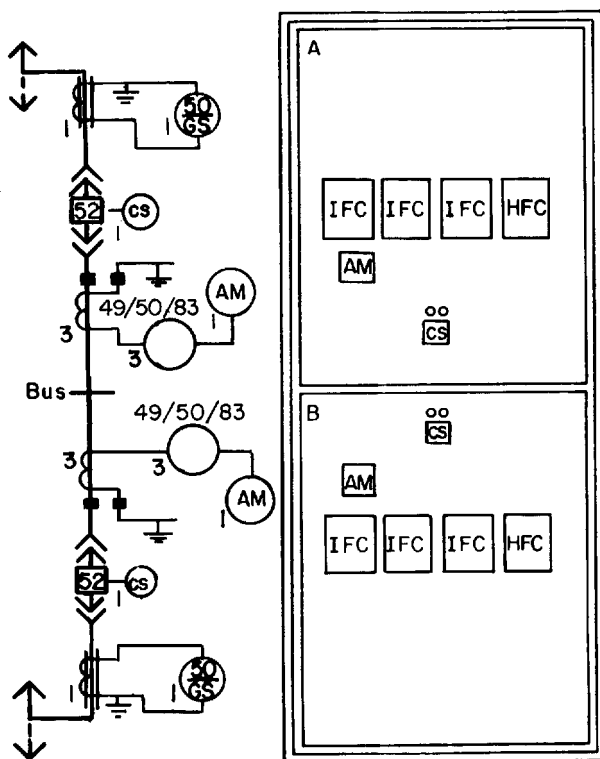
(49/50/83); a Type HFC relay (50GS) for ground-fault protection; and an ammeter for phase 2. No undervoltage protection is included. These relays operate from three current transformers, one in each phase, and a ground sensor CT.

The equipment specified is for use on an impedance grounded or solidly grounded system. See "Optional Equipment Selection" (page 6-30) for modifications of this equipment for use in systems with other types of grounding.

OPTIONAL EQUIPMENT SELECTION

Options for IMFE are discussed on page 6-30.

INDUCTION MOTOR FEEDER (IMFE)



DEVICE LIST FOR IMFE (Unit A or Unit B)

Device	Device No. or Abbr.	Qty	Description or Model No.
Power Circuit Breaker	52	1	VB - (kV) (MVA) (A)
Phase Overcurrent Relay	49/50/83	3	12IFC66K1A
Ground Sensor Relay	50GS	1	12HFC11B1A
Current Transformers	CT	3	JAG-0 (___/5A)
Current Transformer	CT	1	Tech-Tran G.S.
Breaker Control Switch	CS	1	16SB1B9X2
Indicating Lights	IL	2	ET-16, 125V (1-R, 1-G)
Auxiliary Over-Temperature Alarm Relay	49X	1	12HGA
Breaker Closing Fuse Pullout	FU	1	2P-30A (15A Fuses)
Breaker Tripping Fuse Pullout	FU	1	2P-60A (35A Fuses)
Ammeter	AM	1	AB-40
Provisions for Power Conductor Terminations (NEMA Drilling Only)	—	2	Per phase

INDUCTION MOTOR FEEDERS, FULL-VOLTAGE-START (For Motors Less than 1500 HP)

DEFINITION

These metalclad feeder equipments (IMF1) are used for controlling and protecting full-voltage-start motors of less than 1500 hp and are designated as "branch circuit" protective equipment. Economics usually preclude protecting a motor smaller than 1500 hp with a device package as complete as that used for larger motors.

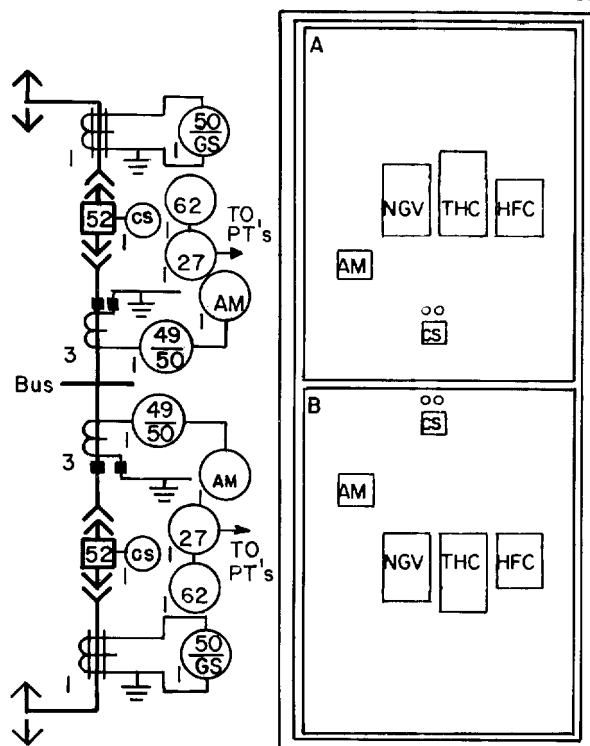
BASIC EQUIPMENT SELECTION

Basic equipment for an IMF1 includes one three-phase Type THC relay for running overload,

locked rotor, and short-circuit protection (49/50); one Type NGV relay and timer for undervoltage protection (27, 62) (only one required per lineup); one Type HFC relay for ground-fault protection (50GS); and an ammeter in phase 2. The over-current relays operate from a total three CT's, one in each phase, and a ground-sensor CT.

The equipment is specified for use on an impedance grounded or solidly grounded system. See "Optional Equipment Selection" (page 6-30) for modifications of this equipment for use on systems with other types of grounding.

INDUCTION MOTOR FEEDER (IMF1)



DEVICE LIST FOR IMF1 (Unit A or Unit B)

Device	Device No. or Abbr.	Qty	Description or Model No.
Power Circuit Breaker	52	1	VB - (kV) (MVA) (A)
Phase Overcurrent Relay	49/50	1	12THC30A A, 3 Element
Ground Sensor Relay	50GS	1	12HFC11B1A
Undervoltage Relay*	27	1	12NGV13B29A
Timer, Agastat*	62	1	7012PB, 0.5-5 sec
Current Transformers	CT	3	JAG-0 (___/5A)
Current Transformer	CT	1	Tech-Tran G.S.
Breaker Control Switch	CS	1	16SB1B9X2
Indicating Lights	IL	2	ET-16, 125V (1-R,1-G)
Breaker Closing Fuse Pullout	FU	1	2P-30A (15A Fuses)
Breaker Tripping Fuse Pullout	FU	1	2P-60A (35A Fuses)
Ammeter (Scale to Match CT)	AM	1	AB-40
Provisions for Power Conductor Terminations (NEMA Drilling Only)	—	2	Per phase

*One required per lineup

INDUCTION MOTOR FEEDERS, FULL-VOLTAGE-START (For Motors 1500 HP and Larger)

DEFINITION

These metalclad feeder equipments (IMF2) are used for controlling and protecting full-voltage-start motors of more than 1500 hp and are designated as "branch circuit" protective equipment. These equipments include differential protection.

BASIC EQUIPMENT SELECTION

Basic equipment for an IMF2 includes three single-phase Type IFC relays (26/50/83) for locked rotor and short-circuit protection; one Type IRT temperature relay (49); one Type NGV undervoltage and timing relay (27, 62); one Type HFC 3-element self-balancing differential relay (87M);

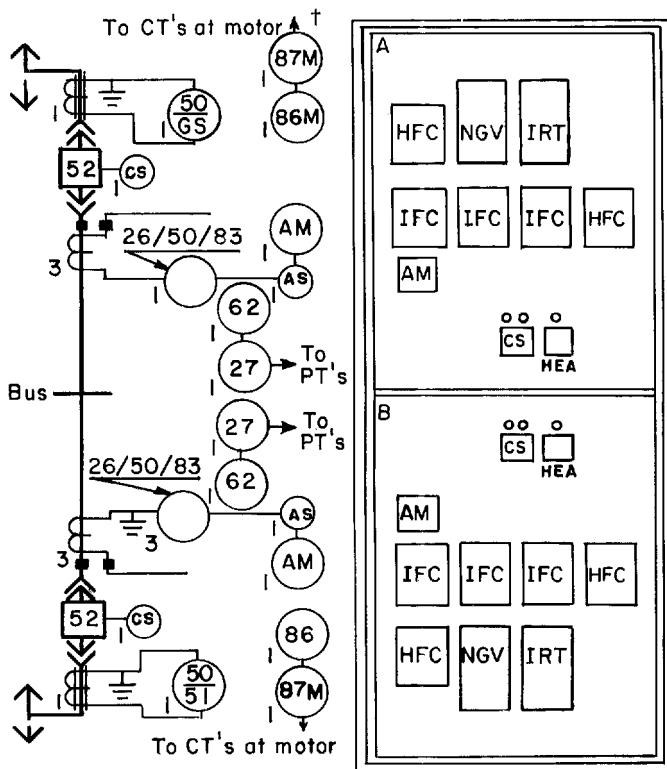
one Type HFC ground-sensor relay (50GS); and an ammeter in phase 2.

The equipment is specified for use on an impedance grounded or solidly grounded system. See "Optional Equipment Selection" (page 6-30) for modifications of this equipment for use on systems with other types of grounding.

MOTOR DIFFERENTIAL PROTECTION

The CT's located at the motor, used for the motor differential (87M) circuit, are designated by "+" below. The purchaser should request the motor manufacturer to supply these CT's; they are not supplied with the switchgear.

INDUCTION MOTOR FEEDER (IMF2)



DEVICE LIST FOR IMF2 (Unit A or Unit B)

Device	Device No. or Abbr.	Qty	Description or Model No.
Power Circuit Breaker	52	1	VB - (kV) (MVA) (A)
Phase Overcurrent Relay	26/50/83	3	121FC66K1A
Ground Sensor Relay	50GS	1	12HFC11B1A
Differential Relay	87M	1	12HFC13B1A
Lockout Relay	86M	1	12HEA61A223X2
Temperature Relay	49	1	12IRT53C6A
Undervoltage Relay*	27	1	12NGV13B29A
Timer, Agastat*	62	1	7012PB, 0.5-5 sec
Current Transformers	CT	3	JAG-0 ()/5A
Current Transformers†	CT	3	JAG-0 ()/5A Remote
Current Transformer Breaker Control Switch	CS	1	Tech-Tran, 50/5, G.S.
Indicating Lights	IL	2	16SB1B9X2
Breaker Closing Fuse Pullout	FU	1	ET-16, 125V (1-R,1-G)
Breaker Tripping Fuse Pullout	FU	1	2P-30A (15A Fuses)
Ammeter (Scale to Match CT)	AM	1	2P-60A (35A Fuses)
Provisions for Power Conductor Terminations (NEMA Drilling Only)	---	2	AB-40
* One required per lineup			

POWER/VAC Switchgear Equipment

OPTIONAL EQUIPMENT SELECTION (For IMFE, IMF1, IMF2)

Protection

For ungrounded systems, omit the ground-sensor overcurrent relay and the current transformer.

When equipment is used to feed more than one motor from the same bus, only one undervoltage relay and one timer are required; however, add Type HFA auxiliary relays (27X), with contacts for each additional motor.

For lineups with bus differential protection, add three current transformers.

Where economically justified, add one 3-element Type HFC instantaneous overcurrent relay operating from the three current transformers (mounted at the motor terminals) and connected for balanced-current motor differential protection (87M).

For motors furnished with RTD coils, omit the Type THC phase-overcurrent relay (49/50) and add one 3-element Type HFC instantaneous overcurrent relay (50) and one Type IRT over-temperature relay (49).

Indication

INSTRUMENTATION AND METERING — For circuits requiring the indication or metering of additional electrical quantities, add indicating varmeter, wattmeter, watthour meter, or watthour demand meter as appropriate. For indication of all three phases of current, add an ammeter switch.

TEST BLOCKS — For circuits which require the provision for insertion of portable recording meters

or other similar devices add current and potential test blocks. Basic current test block is wired to maintain the circuit when the test plug is removed.

INDICATING LAMP — For circuits requiring a circuit breaker disagreement or spring-charged indication function, add a white indicating lamp.

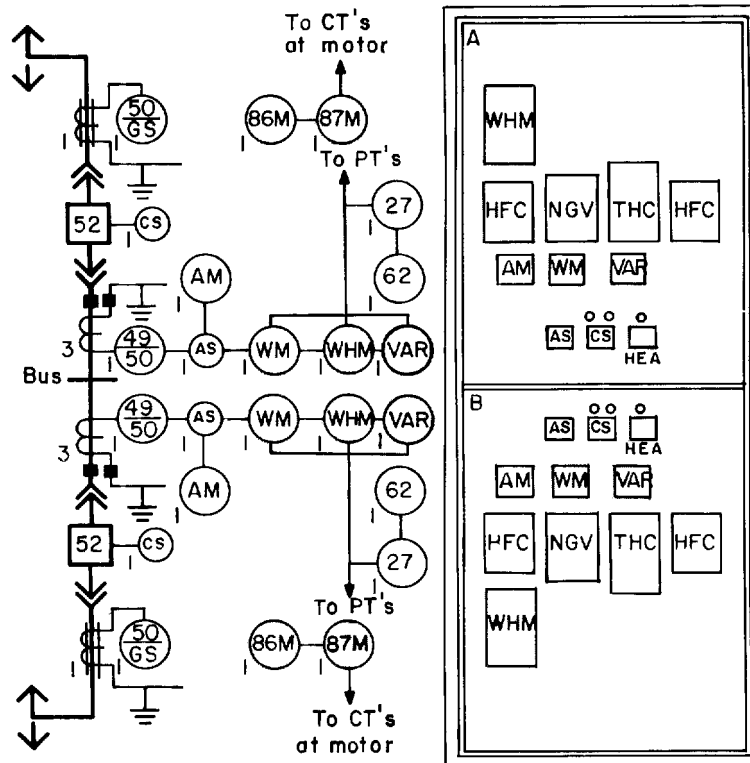
Control

REMOTE CONTROL — For circuit breakers controlled from a remote location, choose the remote control scheme from those listed in Table 5-1 (page 5-7 of this guide.) Scheme C is recommended, since it provides maximum operating flexibility. It requires the use of a breaker position switch in conjunction with the breaker control switch to provide the permissive function. With Scheme C, remote close and trip is possible only with the breaker in the "connected" position; local close with the breaker in the "test" position; and local trip with the breaker in the "connected" or "test" position.

In addition, remote control for motors requires a lockout relay (86), which prevents breaker closing (after a relay-initiated trip) until the lock-out device is manually reset. (The 86 device furnished standard on IMF2 may be used for both 87M and remote control.)

Location of Optional Devices

If several optional devices are added to a motor feeder equipment, there may not be sufficient space to mount them all. In this case, specify that the excess relays are to be mounted on an adjacent auxiliary compartment. This makes the vertical section a custom section.

TYPICAL MODIFICATIONS OF IMFE, IMF1 AND IMF2

DEVICE LIST
(Unit A or Unit B)

All IMF Devices

OMIT: None

ADD:

One DS63 Watthour Meter
One HFC Differential Relay
One AB-40 Wattmeter
One AB-40 Varmeter
One HEA61 Lockout Relay

POWER/VAC Switchgear Equipment

SYNCHRONOUS MOTOR FEEDERS, FULL-VOLTAGE-START, DIRECT-CONNECTED EXCITERS (For Motors Less than 1500 HP)

DEFINITION

These metalclad feeder equipments (SMF1) are used for controlling and protecting full-voltage-start synchronous motors of less than 1500 hp and are designated as motor "branch circuit" protective equipment. Economics usually preclude protecting a motor smaller than 1500 hp with a device package as complete as that used for larger motors.

BASIC EQUIPMENT SELECTION

Basic equipment includes a three-phase Type THC relay (49/50) for running overload, locked rotor, and short-circuit protection; a Type NGV

relay and timer for undervoltage protection; a type HFC relay for ground-fault protection; an ammeter for current indication in phase 2; and field application equipment for a synchronous motor with collector ring excitation. The overcurrent relays operate from a total of three CT's, one in each phase, and a ground-sensor CT.

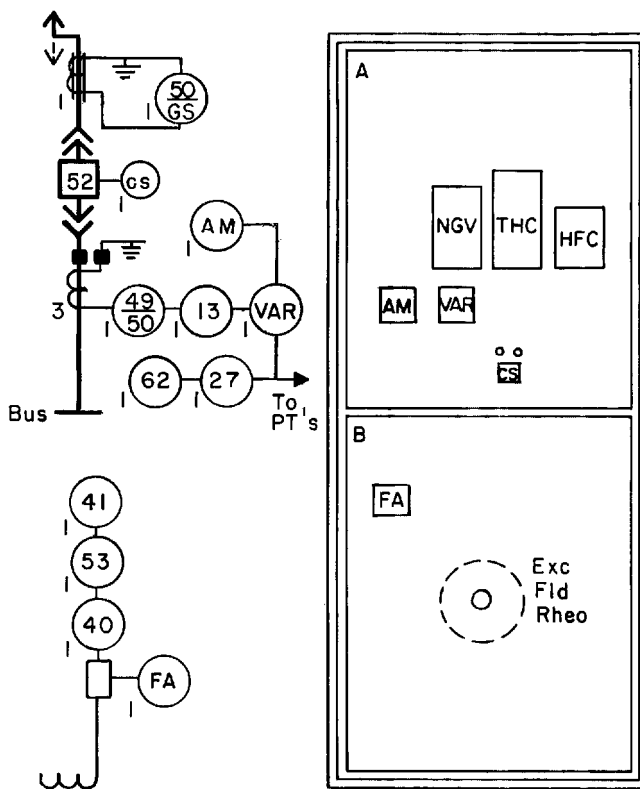
The equipment is specified for use on an impedance grounded or solidly grounded system. See "Optional Equipment Selection" (page 6-34) for modifications of this equipment for use on systems with other types of grounding or having motors with other types of excitation.

SYNCHRONOUS MOTOR FEEDER (SMF1)

DEVICE LIST FOR SMF1 (Unit A AND Unit B)

Device	Device No. or Abbr.	Qty	Description or Model No.
Power Circuit Breaker	52	1	VB - (kV) (MVA) (A)
Phase Overcurrent Relay	49/50	1	12THC30A-A, 3 Element
Ground Sensor Relay	50GS	1	12HFC11B1A
Undervoltage Relay*	27	1	12NGV13B29A
Timer, Agastatt	62	2	7012PB, 0.5-5 sec
Timer, Agastat	48	1	7012PB, 0.5-5 sec
Current Transformers	CT	3	JAG-0 (/5A)
Current Transformer	CT	1	Tech-Tran, 50/5
Breaker Control Switch	CS	1	16SB1B9X2
Indicating Lights	IL	2	ET-16, 125V (1-R,1-G)
Breaker Closing Fuse Pullout	FU	1	2P-30A (15A Fuses)
Breaker Tripping Fuse Pullout	FU	1	2P-60A (35A Fuses)
Drilling & Wiring for Exc. Fld. Rheo.		1	
Ammeter (Scale to Match CT)	AM	1	AB-40
Varmeter	VARM	1	AB-40
Field Ammeter	FA	1	DB-40
Field Shunt		1	
Provisions for Power Conductor Terminations (NEMA Drilling Only)	—	2	Per phase
FIELD APPLICATION DEVICES			
Exciter Relay	53	1	IC2820A100BB
Field Contactor	41	1	IC2812
Field Discharge Res.		1	

*One required per lineup



Field Forcing Res.	1	
Rotor Thermal Dev.	26	1 IC2820F102
Auxiliary Relay	41X	1 12HFA65
Slip Guard Relay	55	1 IC3655A100C
Field Application Pnl.	13,X,Y	1 0114C4063

SYNCHRONOUS MOTOR FEEDERS, FULL-VOLTAGE-START, DIRECT-CONNECTED EXCITERS (For Motors 1500 HP and Larger)

DEFINITION

These metalclad feeder equipments (SMF2) are used for controlling and protecting full-voltage-start synchronous motors of more than 1500 hp and are designated as motor "branch circuit" protective equipment. These equipments include differential protection.

BASIC EQUIPMENT SELECTION

The basic equipment includes the same devices

as those listed for SMF1, plus the differential relay equipment described as optional equipment for the SMF1.

MOTOR DIFFERENTIAL PROTECTION

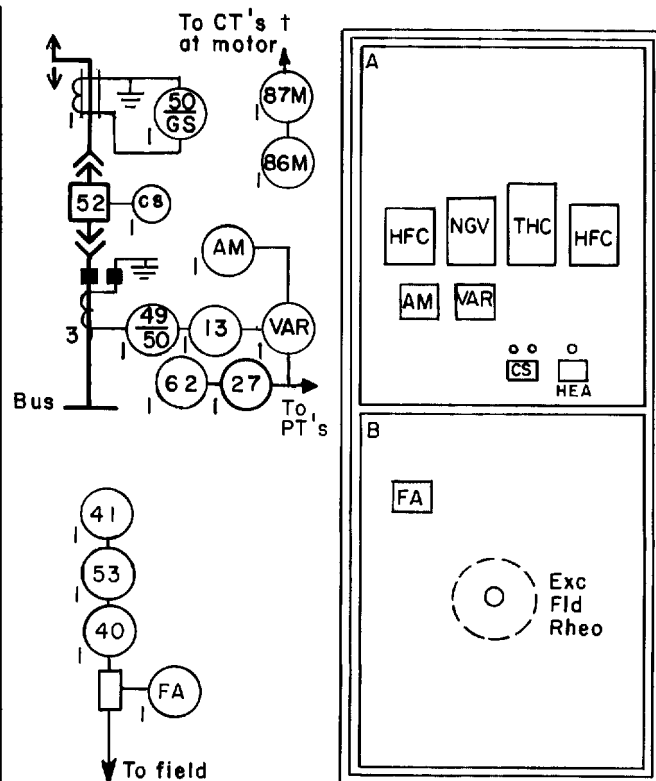
The CT's located at the motor, used for the motor differential (87M) circuit, are designated by "+" below. The purchaser should request the motor manufacturer to supply these CT's; they are not supplied with the switchgear.

SYNCHRONOUS MOTOR FEEDER (SMF2)

DEVICE LIST FOR SMF2 (Unit A AND Unit B)

Device	Device No. or Abbr.	Qty	Description or Model No.
Power Circuit Breaker	52	1	VB - (kV) (MVA) (A)
Phase Overcurrent Relay	49/50	1	12THC30A-A, 3 Element
Ground Sensor Relay	50GS	1	12HFC11B1A
Differential Relay	87M	1	12HFC13B1A
Lockout Relay	86M	1	12HEA61A223X2
Undervoltage Relay*	27	1	12NGV13B29A
Timer, Agastat *	62	1	7012PB, 0.5-5 sec
Timer, Agastat	48	1	7012-C 1.5-15 sec
Current Transformers	CT	3	JAG-0 (/5A)
Current Transformers †	CT	3	JAG-0 (/5A) Remote
Current Transformer	CT	1	Tech-Tran, 50/5A, G.S.
Breaker Control Switch	CS	1	16SB1B9X2
Indicating Lights	IL	2	ET-16, 125V (1-R,1-G)
Breaker Closing Fuse Pullout	FU	1	2P-30A (15A Fuses)
Breaker Tripping Fuse Pullout	FU	1	2P-60A (35A Fuses)
Drilling & Wiring for Exc.Fld.Rheo.		1	
Ammeter (Scale to Match CT)	AM	1	AB-40
Varmeter	VAR	1	AB-40
Field Ammeter	FA	1	DB-40
Field Shunt		1	
Provisions for Power Conductor Terminations (NEMA Drilling Only)	—	2	Per phase
FIELD APPLICATION DEVICES			
Exciter Relay	53	1	IC2820A100BB
Field Contractor	41	1	IC2812

*One required per lineup



Field Discharge Res.	1	
Field Forcing Res.	1	
Rotor Thermal Dev.	26	1 IC2820F102
Auxiliary Relay	41X	1 12HFA65
Slip Guard Relay	55	1 IC3655A100C
Field Application Pnl.	13,X,Y	1 0114C4063

Synchronous Motor
Feeders
6

OPTIONAL EQUIPMENT SELECTION (For SMF1 and SMF2)

Protection

If the equipment being protected has RTD's, omit one Type THC three-phase thermal relay (49/50) and add one Type IRT thermal relay (49) operating from RTD, plus three Type IFC66K overcurrent relays (26/50/83).

If six-CT machine differential relaying (87M) is desired, omit one three-phase Type HFC instantaneous relay and three CT's (supplied by motor manufacturer) at the machine terminals. Add three Type CFD differential relays and six CT's (three in machine neutral leads and three in metalclad switchgear).

For ungrounded systems, omit the ground-sensor overcurrent relay (50GS) and the current transformer.

When equipment is used to feed more than one motor from the same bus, only one undervoltage relay and one timer are required; however, add Type HFA auxiliary relay (s) (27X), with contacts for each additional motor.

If the motor is part of a motor-generator set or drives a synchronous condenser, add one Type IAC60 extreme overload relay (51R).

Where economically justified, add one 3-element Type HFC instantaneous overcurrent relay operating from the three current transformers (mounted at the motor terminals) and connected for balanced-current motor differential protection (87M).

Excitation

For motors with collector ring excitation and for which solid-state field application equipment is desired, omit the field application equipment included in the basic equipment and add appropriate field application panel.

If solid-state field application equipment is desired for motors with brushless excitation, omit the field application equipment included in the basic equipment and add appropriate field application panel.

These two application panels are considered custom design.

Indication

INSTRUMENTATION AND METERING — For circuits requiring the indication or metering of additional electrical quantities, add an indicating varmeter, a wattmeter, a watthour meter, or a watthour demand meter as appropriate. For indication of all three phases of current, add an ammeter and switch.

TEST BLOCKS — For circuits which require the provision for insertion of portable recording meters or other similar devices, add current and potential test blocks. Basic current test block is wired to maintain the circuit when the test plug is removed.

INDICATING LAMP — For circuits requiring a circuit breaker disagreement or spring-charged indication function, add a white indicating lamp.

Control

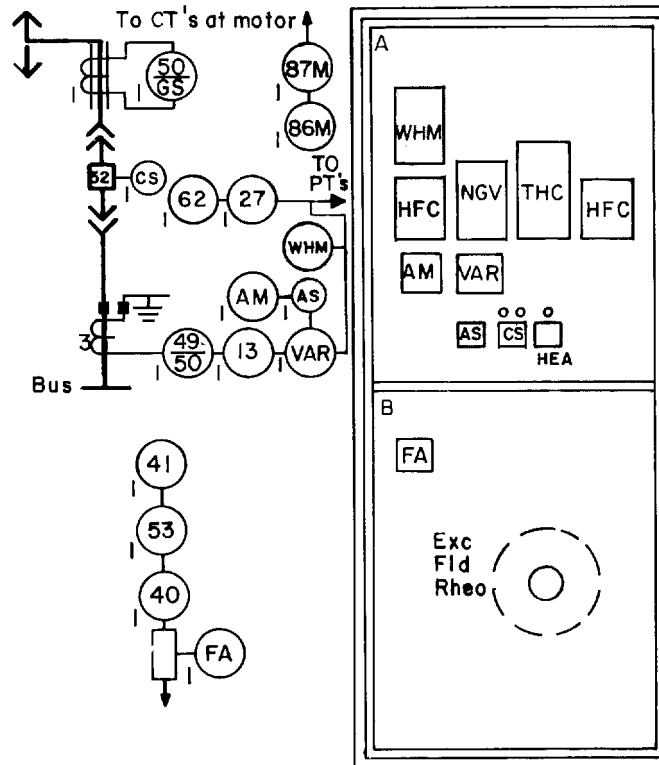
REMOTE CONTROL — For circuit breakers controlled from a remote location, choose the remote control scheme from those listed in Table 5-1 (page 5-7 of this guide.) Scheme C is recommended, since it provides maximum operating flexibility. It requires the use of a breaker position switch in conjunction with the breaker control switch to provide the permissive function. With Scheme C, remote close and trip is possible only with the breaker in the "connected" position; local close with the breaker in the "test" position; and local trip with the breaker in the "connected" or "test" position.

In addition, remote control for motors requires a lockout relay (86), which prevents breaker closing (after a relay-initiated trip) until the lockout device is manually reset. (The 86 device furnished standard on SMF2 may be used for both 87M and remote control.)

Location of Optional Devices

If several optional devices are added to a motor feeder equipment, there may not be sufficient space to mount them all. In this case, specify that the excess relays are to be mounted on an adjacent auxiliary compartment. This makes the vertical section a custom section.

TYPICAL MODIFICATIONS OF SMF1 AND SMF2



DEVICE LIST
(Unit A AND Unit B)

All SMF Devices

OMIT: None

ADD:

One DS63 Watthour Meter
One HFC Differential Relay
One HEA-61 Lockout Relay
One SB-1 Ammeter Switch

POWER/VAC Switchgear Equipment

GENERATORS

DEFINITION

Generator metalclad equipment (GEN) controls and protects a synchronous generator driven by a steam turbine, gas turbine, a diesel engine, a gasoline engine, a water-wheel turbine, or a motor. The generator may be operated as an isolated system source or in parallel with other power sources. The basic equipment specified here is adaptable to any of these circumstances with the addition of the proper optional equipment. Most generator equipments are custom.

BASIC EQUIPMENT SELECTION

The basic equipment includes no field control or voltage regulator equipment, since this equipment is normally supplied with the generator and located in a separate cubicle either adjacent to the generator or near the switchgear.

Field Control and Voltage Regulation

To obtain field control for remote-mounted field equipment, add one motor-operated rheostat control switch and one field ammeter.

For generators with brushless exciters and without remote SC-PT regulators, add one metalclad equipment vertical section containing provision for mounting a voltage regulator, brushless exciter field control, mounting for an exciter field rheostat, and an exciter field ammeter. Add one or two PT's and one CT to the generator circuit breaker vertical section for use with the voltage regulator, if required.

Protection

STEAM-TURBINE GENERATORS — For generators requiring anti-motoring protection, add a Type GGP directional power relay (32).

OTHER THAN STEAM-TURBINE GENERATORS — For generators requiring anti-motoring

protection, add one Type ICW directional power relay (32).

FOR GENERATORS ON GROUNDED SYSTEMS — Add one Type IFC ground overcurrent relay (51G).

FOR GENERATORS OPERATING IN PARALLEL WITH OTHER POWER SOURCES ON GROUNDED SYSTEMS — Add one Type ICC directional ground relay (67N).

FOR LARGER GENERATORS — Add one Type CEH loss-of-field relay (40), one Type INC or SGC negative sequence current relay (46), and one Type CFVB voltage-balance relay (60).

Synchronizing

To synchronize machine to bus, add a synchronizing bracket with two voltmeters, a frequency meter, a synchroscope, and two indicating lamps.

For automatic synchronizing, add a Type GES automatic synchronizing relay (25), a Type GTL speed-matching relay (15L & R), and a Type IJS cut-off relay (25A).

Isolated Systems

Omit the synchronizing switch and add one frequency meter and a voltmeter.

Current Transformers

Add three current transformers for lineups that include bus differential protection.

Indication and Metering

For generators requiring supplementary indication and metering, add one Type DB-40 temperature meter and a transfer switch for monitoring three RTD's, one Type KT time meter, one Type DS-63 watt-hour meter, one Type DSM-63 watt-hour demand meter, and Type PK-2 current or potential test blocks.

6

Generators



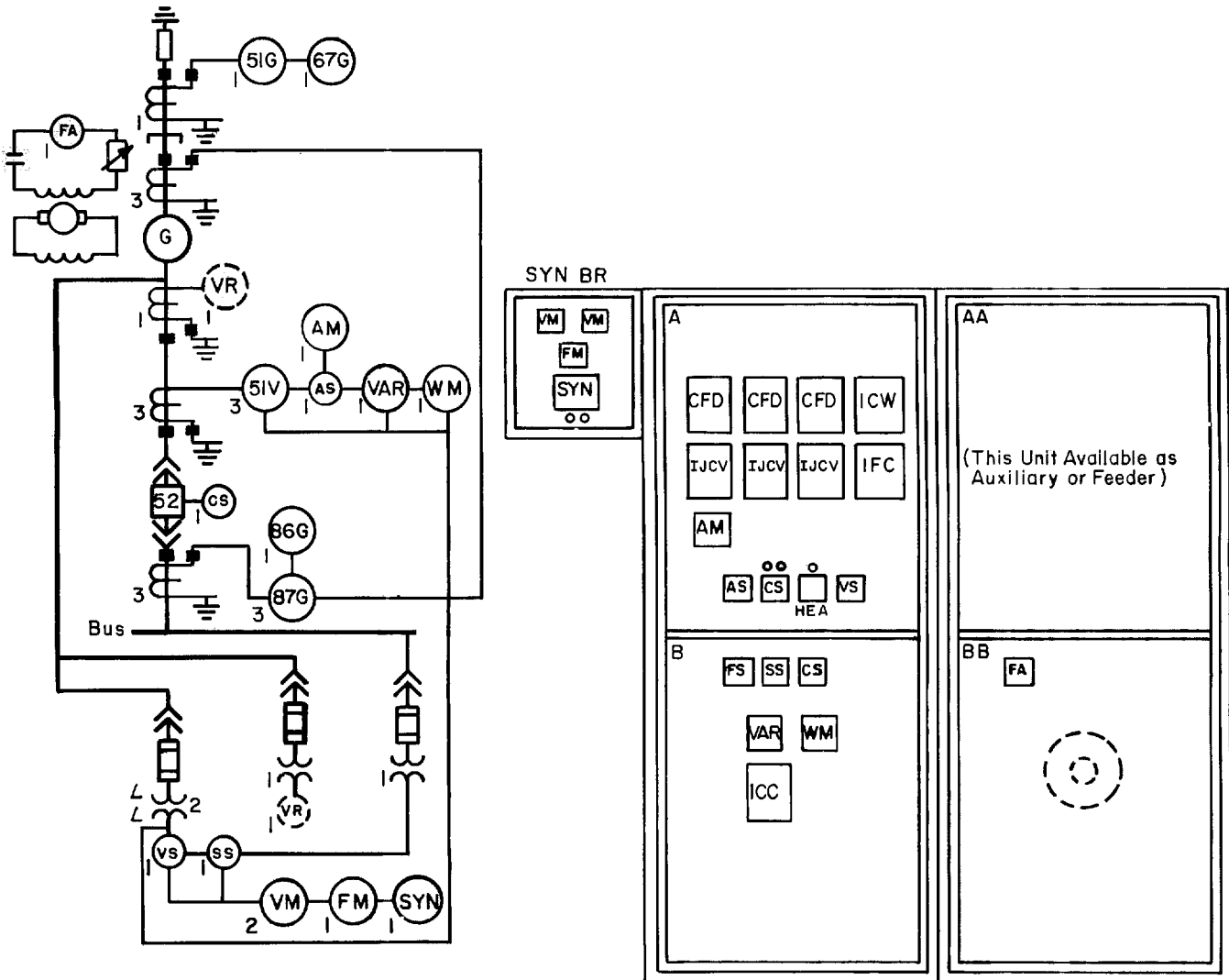
Generators

Generators

Generators

Generators

TYPICAL MODIFICATIONS OF GEN



DEVICE LIST (Unit A AND Unit B)

All GEN Devices
 Parallel Operation
 (Larger Diesel Brushless Generator)

OMIT: None

ADD:

One ICC51 Directional Overcurrent Relay
 One Potential Transformer
 One Field Control Switch

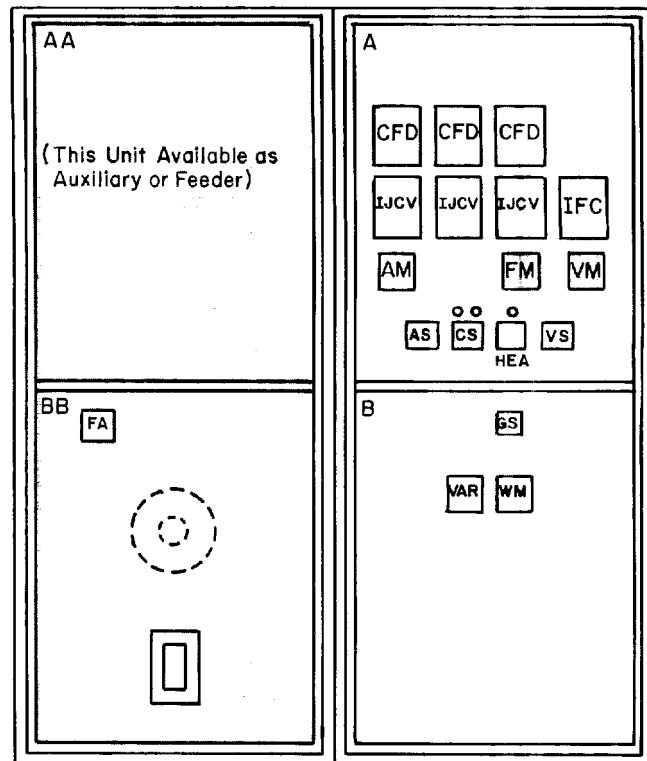
DEVICE LIST (Unit AA AND Unit BB)

All GEN Devices
 Parallel Operation
 (Larger Diesel Brushless Generator)

OMIT: None

ADD:

One Potential Transformer
 One Field Ammeter
 Provision for Mounting Exciter Field Control
 Synchronizing Bracket Per Basic Specification



Provision for Mounting Voltage Regulator
Provision for Mounting Field Rheostat
One DB-40 Field Ammeter and Shunt
One Field Breaker

One Voltmeter
One Potential Transformer

POWER/VAC Switchgear Equipment

MATRIX SUMMARY OF OPTIONS

ADDITIONS:

NOTE: NOT ALL ADDITIONS MAY BE MADE TO A SINGLE VERTICAL SECTION. SEE EXAMPLES FOR LIMITS.

Item	Qty.	Description	GPF	BBF	TPF	SSIL	DSIL	BT	BE	IMFE	IMF1	IMF2	SMF1	SMF2	GEN
INSTRUMENTS, METERS, AND SWITCHES															
1	1	Voltmeter, Type AB-40 and switch	•	•	•				•						•
2	1	Voltmeter, Type AB-40													•
3	1	Wattmeter, Type AB-40				•	•			•	•	•	•	•	
4	1	Varmeter, Type AB-40				•	•			•	•	•			
5	1	Ammeter, Type AB-40 and switch						•	•						
6	3	Ammeters, Type AB-40							•						
7	1	Switch, ammeter, Type SB-1								•	•	•	•	•	
8	1	Meter, frequency, Type AB-40													•
9	1	Meter, temperature, Type DB-40													•
10	1	and transfer switch, Type SB-1													•
10	1	Synchronizing Bracket													•
11	1	Watthour meter, Type DS-63, 2-element	•	•	•	•	•		•	•	•	•	•	•	•
		or													
	1	Watthour demand meter, Type DSM-63, 2-element, 15 minute, secondary reading	•	•	•	•	•	•	•	•	•	•	•	•	•
12	1	Current test block, 4-pole, Type PK-2	•	•	•	•	•	•	•	•	•	•	•	•	•
13	1	Potential test block, 4-pole, Type PK-2	•	•	•	•	•	•	•	•	•	•	•	•	•
14	1	White indicating lamp (breaker disagreement or latch checking)	•	•	•	•	•	•		•	•	•	•	•	•

CURRENT TRANSFORMERS

15	3	For local or remote bus differential relays	•	•	•	•	•	•	•	•	•	•	•	•	•
16	3	For local or remote transf. diff. relays	•	•		•	•	•							
17	3	For current summing						•							
18	2 or 3	For optional instruments and meters						•	•						
19	1	For voltage regulator													•

POTENTIAL TRANSFORMERS

20	1,2,3	Potential transformers							•						•
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RELAYS

21	1	Relay, reclosing, Type NLR (79) and switch	•	•											
----	---	--	---	---	--	--	--	--	--	--	--	--	--	--	--

For Lineups Fed From Transformers With Fused Primaries

22	1	Relay, negative sequence voltage, Type NBV (60)				•	•				•	•	•	•	
	1	Timer, Agastat 0.5-2.0 seconds (62)													
	3	Relays, current balance, Type IJC (60C)					•								

Bus-differential Relaying

23	3	Relays, bus differential, Type PVD (87B)				•	•	•							
	1	Relay, lockout, Type HEA (86B) and white indicating lamp						•	•						

For Lineups Fed From Transformers With Primary Breakers

24	3	Relays, transformer differential, Type STD													
	1	Relay, transformer fault pressure aux., Type HAA (63FPX)				•	•								
	1	Relay, lockout, Type HEA (86T) and white indicating lamp													
25	1	Relay, transformer ground differential, Type IFD (87TG) and aux. JAR-0 CT				•	•								

•• Indicates possible need for double quantities.

Section 6

Item	Qty.	Description	GPF	BBF	TPF	SSIL	DSIL	BT	BE	IMFE	IMF1	IMF2	SMF1	SMF2	GEN
For Systems With Local Generation (or Subject to Reclosing) (one each per lineup)															
26	1	Relay, frequency, Type SFF (81)				•	•								
27	1	Relay, directional power, Type CCP (32)				•	•								
28	1	Relay, undervoltage, Type NGV (27)				•	•								
	1	Timer, Agastat, 0.5-2.0 secs. (62)													
For Motor Circuits															
29	1	Relay, motor differential, Type HFC, 3-el., (87M)								•	•		•		
29A	1	Relay, lockout, Type HEA (86M)								•	•		•		
30	1	Relay, temperature, Type IRT (49)								•	•		•	•	
For Generators Operating In Parallel															
31	1	Relay, directional ground, Type ICC (67N)													•
	1	Relay, overcurrent ground, Type IFC (51G)													•
32	1	Relay, anti-motoring, Type ICW (32)													•
33	1	Relay, anti-motoring, Type GGP (32)													•
For Larger Generators															
34	1	Relay, loss-of-field, Type CEH (40)													•
35	1	Relay, negative sequence, Type INC (46)													•
36	1	Relay, voltage balance, Type CFVB (60)													•
Incoming Line Automatic Throwover With Tie Breaker															
37	2	Relays, undervoltage, Type NGV (27-1, -2)					•								
	2	Relays, undervoltage and phase sequence, Type ICR (47-1, -2)													
	2	Relays, auxiliary, Type HFA (27X-1, -2)													
	2	Relays, time delay, Agastat (2, 62)													
	1	Switch, manual automatic, Type SB-1 (43)													
Auxiliary Relays															
38	1	Relay, auxiliary, Type HFA (27X)									•	•	•	•	
REMOTE CONTROL															
39	1	Switch, breaker position, Type SB-12	•	•	•	•	•	•			•		•		
40	1	Switch, breaker position, Type SB-12, and lockout relay, Type HEA (86M)								•	•		•		
OMISSIONS:															
INSTRUMENTS AND METERS															
1	1	Voltmeter and voltmeter switch				•	•								
	2	Potential transformers													
RELAYS AND SWITCHES															
2	1	Relay, phase overcurrent (51)	•	•	•	•	•								
	1	Current transformer (phase 2)													
3	1	Relay, phase overcurrent	•	•	•	•	•								
For Ungrounded Systems															
4	1	Relay, directional ground 12IBCG53K3A (67N)					•								
	1	Relay, ground overcurrent 12IFC53A2A (51N)													
For Motor Circuits															
5	1	Relay, undervoltage 12NGV13B29A (27)									•	•	•	•	
	1	Timer, Agastat (62)													
6	1	Relay, ground-sensor 12HFC11B1A (50GS)								•	•	•	•	•	
	1	Ground-sensor current transformer													
For Isolated Generators															
7	1	Switch, synchronizing													•

POWER/VAC Switchgear Equipment

SUBSTITUTIONS:

Item	Description	GPF	BBF	TPF	SSIL	DSIL	BT	BE	IMFE	IMF1	IMF2	SMF1	SMF2	GEN
CONTROL VOLTAGE														
1	Omit 125V, dc control Add required control voltage (see Section 4 of this guide)	•	•	•	•	•	•		•	•	•	•	•	•
REMOTE CONTROL														
2	Omit breaker control switch, or omit all devices Add permissive switch (69)	•	•	•	•	•	•				•		•	
3	Omit breaker control switch or omit all devices Add permissive switch (69) and lockout relay, Type HEA (86M)								•	•		•		
INSTRUMENTS AND METERS														
4	Omit 1 ammeter and switch Add 3 ammeters, Type AB-40	•	•	•	•	•	•							
PHASE AND GROUND OVERCURRENT RELAYS														
5	Omit 2 or 3 phase overcurrent relays, Type IFC53 Add 2 or 3 phase overcurrent relays from device list*	•	•	•	•	•								
6	Omit 1 ground-sensor relay, Type HFC (50GS) Add 1 ground-sensor relay, Type IFC (51GS)	•	•	•										
7	Omit 1 residual ground relay, Type IFC53 (51N) Add 1 residual ground relay from device list*	•	•	•	•	•								
Lineups With Tie Breakers														
8	Connect phase and ground overcurrent relays for sum of current (partial differential)				•	•	•							
Motor Circuits														
9	Omit 1 phase overcurrent relay, Type THC (49/50) Add 1 instant, o.c. relay, Type HFC 3-el. (50) Add 1 thermal relay, Type IRT (49)										•		•	
Lineups Fed From Lines With Remote-ground Transformers														
10	Omit 1 machine differential relay, Type HFC (87M) and 3 CT's at machine Add 3 relays, Type CFD (87M) and 6 CT's (3 at machine)										•		•	
11	Omit 2 potential transformers connected open-delta Add 3 potential transformers connected wye-wye, plus 3 auxiliary PT's connected wye-broken delta					•								

*See Table 7-1

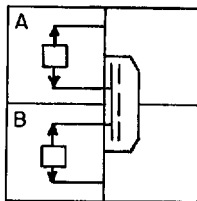
POWER CONDUCTOR COMPARTMENTS AND AUXILIARY UNITS

This section covers the arrangement of power conductor and auxiliary units in the vertical switchgear sections. Nine combinations of power conductor compartments are shown. For each combination, the basic arrangement is shown at the top of the page. Selection of one or more of the options determines the minimum depth of the indoor vertical section selected, as indicated in the option tables. (All outdoor units are 97 inches deep, plus depth of protected aisle, if specified.)

All indoor vertical sections are 95 inches high and 36 inches wide. Outdoor vertical sections are approximately 112 inches high.

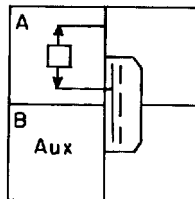
Window-type phase CT's (up to two per breaker bushing) are mounted in the breaker compartment. See Table 7-33 for ratings.

Breaker in A
Breaker in B



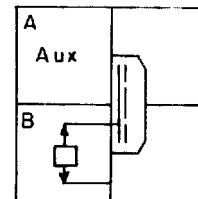
page
6-44

Breaker in A
Auxiliary B



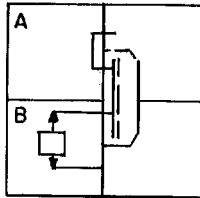
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6-45

Auxiliary A
Breaker B



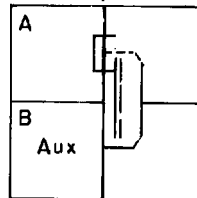
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6-46

Bus entrance in A (or B)
Breaker in B (or A)



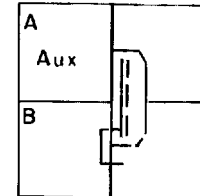
page
6-47

Bus entrance in A
Auxiliary B



page
6-48

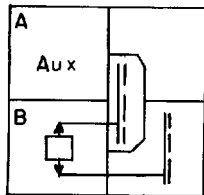
Auxiliary in A
Bus entrance in B



page
6-49

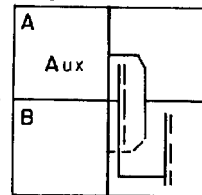
Bus tie

Auxiliary in A
Tie breaker in B
(Left section)



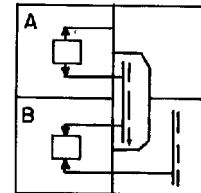
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6-50

Auxiliary in A
Tie aux in B
(Right section)



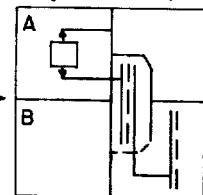
Bus tie

Breaker in A
Tie breaker in B
(Left section)

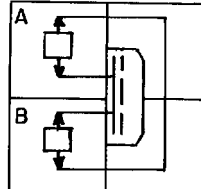


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6-51

Breaker in A
Tie aux in B
(Right section)

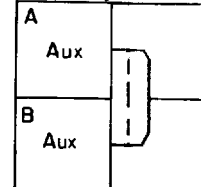


Feeder by-pass
Breaker in A
Breaker in B



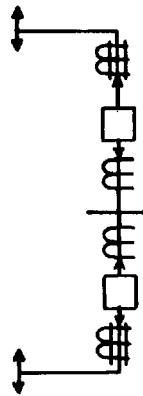
page
6-52

Auxiliary
Auxiliary A
Auxiliary B

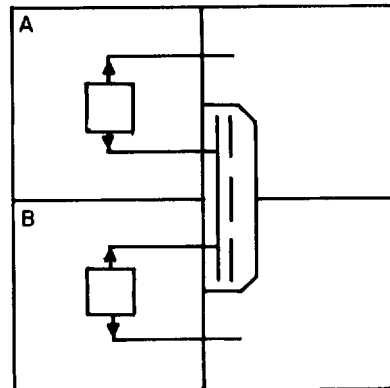


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POWER/VAC Switchgear Equipment



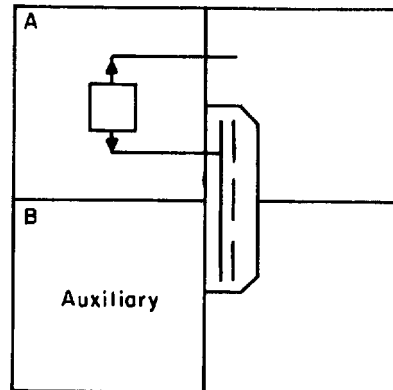
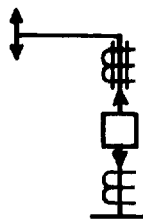
Breaker in A
Breaker in B



		82 IN. DEEP VERTICAL SECTIONS	94 IN. DEEP VERTICAL SECTIONS
RATINGS	BUS	1200, 2000, or 3000 A	
	BREAKERS	Both 1200 A or top 1200 A/bottom 2000 A	
ENTERING POWER CONDUCTORS	TYPE	Shielded, non-leaded cable	
	DIRECTION	Top circuit from above and bottom circuit from below	
			Both circuits from below
			Both circuits from above
	TERMI-NATION	Provision for 2 terminals per phase (NEMA drilling less terminals) up to and including 750 MCM for each circuit (21" allowed for stress cones)	

OPTIONS

CT's		Add small ground sensor (7" window) to either or both circuits	
			Add 2 or 3 wound type phase CT's per circuit to either or both circuits
TERMINALS		Add Burndy Hylug terminals per Tables 7-45, 7-46 to either or both circuits	
		Add clamp type terminals per Tables 7-45, 7-46 to either or both circuits	
POTHEADS		Add 1-3/C or 3-1/C potheads per circuit to either or both circuits. No ground sensors or wound type CT's on either circuit	
			Add 6-1/C potheads to either circuit (not both). No ground sensor or wound type CT's on either circuit
ROOF BUSHINGS (OUTDOOR ONLY)			Add 3 roof bushings to top circuit.(no ground sensor); bottom circuit out below.
METAL-ENCLOSED BUS			Add termination for metal-enclosed bus from above to top circuit (no ground sensor); bottom circuit out above or below
			Add termination for metal-enclosed bus from below to bottom circuit (no ground sensor); top circuit out above or below

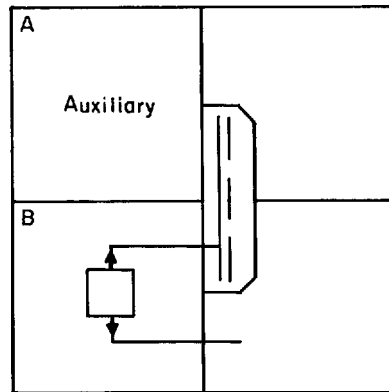
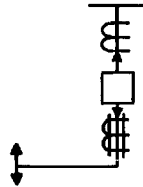
Breaker in A
Auxiliary in B

		82 IN. DEEP VERTICAL SECTIONS	94 IN. DEEP VERTICAL SECTIONS
RATINGS	BUS	1200, 2000 or 3000 A	
	BREAKERS	1200 or 2000 A	
ENTERING POWER CONDUCTORS	TYPE	Shielded, non-leaded cable	
	DIRECTION	From above or below except above only when CPT mounted in bottom rear of Unit B	
	TERMINATION	Provision for 2 terminals per phase (NEMA drilling less terminals) up to and including 750 MCM (21" allowed for stress cones)	

CT's		Add small ground sensor (7" window)	
		Add large ground sensor (12" window)	
		Add 2 or 3 wound type phase CT's	
TERMINALS			Add provision for a total of 4 terminals per phase (NEMA drilling less terminals) up to and including 750 MCM (25" allowed for stress cones)
		Add Burndy Hylug terminals per Tables 7-45, 7-46.	
		Add clamp type terminals per Tables 7-45, 7-46.	
POTHEADS		Add 3-1/C or 1-3/C potheads above or below; add 6-1/C or 2-3/C potheads above; (no ground sensors). (Above only when CPT mounted in bottom power conductor compartment)	
			Add 6-1/C or 2-3/C potheads below (no ground sensors); (no CPT in bottom power conductor compartment)
ROOF BUSHINGS (OUTDOOR ONLY)			Add 3 roof bushings (no ground sensor)
METAL-ENCLOSED BUS		Add termination for metal-enclosed bus from above or below (from above only when CPT mounted in bottom near Unit B)	

POWER/VAC Switchgear Equipment

Auxiliary in A
Breaker in B



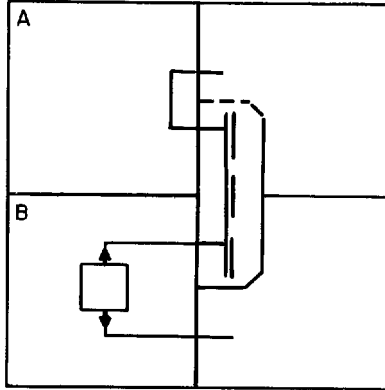
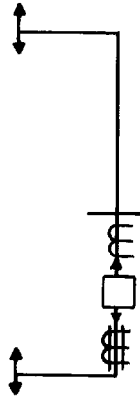
		82 IN. DEEP VERTICAL SECTIONS	94 IN. DEEP VERTICAL SECTIONS
RATINGS	BUS	3000 A	
	BREAKERS	3000 A	
ENTERING POWER CONDUCTORS	TYPE	Shielded, non-leaded cable	
	DIRECTION	From above or below	
	TERMI-NATION	Provision for 2 terminals per phase (NEMA drilling less terminals) up to 750 MCM (21" allowed for stress cones)	

OPTIONS

CT's		Add small ground sensor (7" window)	
		Add large ground sensor (12" window)	
		Add 2 or 3 wound type phase CT's	
TERMINALS			Add provision for a total of 4 terminals per phase (NEMA drilling less terminals) up to and including 750 MCM (25" allowed for stress cones)
		Add Burndy Hylug terminals per Tables 7-45, 7-46.	
		Add clamp type terminals per Tables 7-45, 7-46.	
POTHEADS		Add 3-1/C or 1-3/C potheads above or below; add 6-1/C or 2-3/C potheads above (no ground sensor)	
			Add 6-1/C or 2-3/C potheads below (no ground sensor)
ROOF BUSHINGS (OUTDOOR ONLY)			Add 3 roof bushings (no ground sensor)
METAL-ENCLOSED BUS		Add termination for metal-enclosed bus above or below	

Section 6

Bus Entrance in A (or B)
Breaker in B (or A)



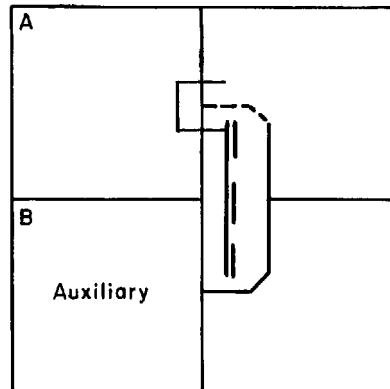
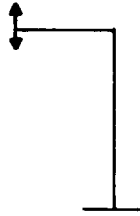
		82 IN. DEEP VERTICAL SECTIONS	94 IN. DEEP VERTICAL SECTIONS
RATINGS	BUS	1200, 2000, or 3000 A	
	BREAKERS	1200 or 2000 A bus entrance, 1200 A breaker	
ENTERING POWER CONDUCTORS	TYPE	Shielded, non-leaded cable	
	DIRECTION	Top circuit from above and bottom circuit from below	
			Both circuits from below Both circuits from above
	TERMI- NATION	Provision for 2 terminals per phase (NEMA drilling less terminals) up to and including 750 MCM for each circuit (21" allowed for stress cones)	
OPTIONS			
CT's		Add small ground sensor (7" window) to breaker circuits	
		Add window type phase CT's to top bus entrance circuit	
			Add large ground sensor CT (12" window) to breaker end
			Add 2 or 3 wound type phase CT's to breaker circuit
TERMINALS		Add Burndy Hylug terminals per Tables 7-45, 7-46 to either or both circuits	
		Add clamp type terminals per Tables 7-45, 7-46 to either or both circuits	
			Add provision for total of 4 terminals per phase (NEMA drilling less terminals) up to and including 750 MCM for either or both circuits (25" allowed for stress cones)
POTHEADS		Add 1-3/C or 3-1/C potheads per circuit to either or both circuits. No ground sensors or wound type CT's on either circuit	
			Add 6-1/C potheads to either circuit (not both). No ground sensor or wound type CT's on either circuit
ROOF BUSHINGS (OUTDOOR ONLY)			Add 3 roof bushings to top circuit (no ground sensor); bottom circuit out below
METAL-ENCLOSED BUS			Add termination for metal-enclosed bus from above to top circuit (no ground sensor); bottom circuit out above or below)
			Add termination for metal-enclosed bus from below to bottom circuit (no ground sensor); top circuit out above or below

Power Conductor
Compartment and
Auxiliary Units

6

POWER/VAC Switchgear Equipment

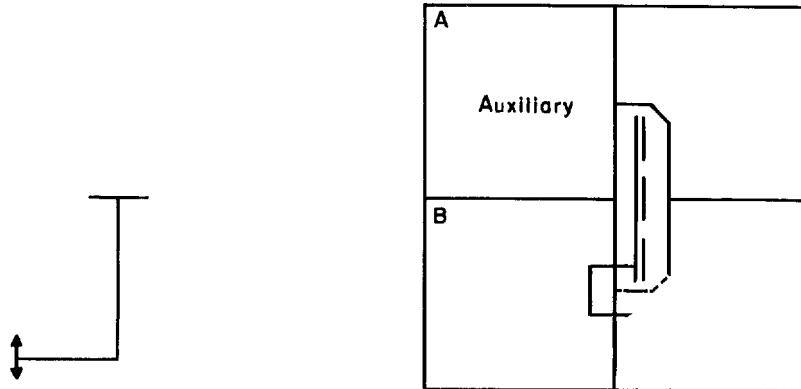
Bus Entrance in A
Auxiliary in B



		82 IN. DEEP VERTICAL SECTIONS	94 IN. DEEP VERTICAL SECTIONS
RATINGS	BUS	1200, 2000 or 3000 A	
	ENTRANCE	1200 or 2000 A	
ENTERING POWER CONDUCTORS	TYPE	Shielded, non-leaded cable	
	DIRECTION	From above or below except above only when CPT mounted in bottom power conductor compartment	
	TERMI- NATION	Provision for 2 terminals per phase (NEMA drilling less terminals) up to and including 750 MCM (21" allowed for stress cones)	

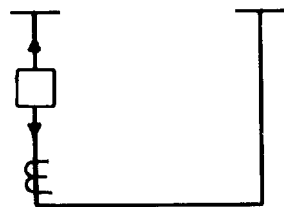
CT's		Add 2 or 3 wound type phase CT's	
		Add window type phase CT's to top bus entrance compartment	
TERMINALS			Add provision for a total of 4 terminals per phase (NEMA drilling less terminals) up to and including 750 MCM (25" allowed for stress cones)
		Add Burndy Hylug terminals per Tables 7-45, 7-46.	
		Add clamp type terminals per Tables 7-45, 7-46.	
POTHEADS		Add 3-1/C or 1-3/C potheads above or below; add 6-1/C or 2-3/C potheads above; (no ground sensors). (Above only when CPT mounted in bottom power conductor compartment)	
			Add 6-1/C or 2-3/C potheads below (no ground sensors); (no CPT in bottom power conductor compartment)
ROOF BUSHINGS (OUTDOOR ONLY)			Add 3 roof bushings (no ground sensor)
METAL-ENCLOSED BUS		Add termination for metal-enclosed bus from above or below (from above only when CPT mounted in bottom power conductor compartment)	

Auxiliary in A
Bus Entrance in B

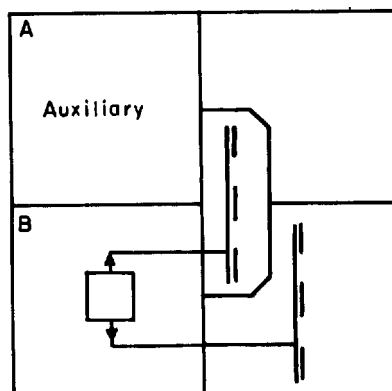


		82 IN. DEEP VERTICAL SECTIONS	94 IN. DEEP VERTICAL SECTIONS
RATINGS	BUS	1200, 2000, or 3000 A	
	ENTRANCE	3000 A	
ENTERING POWER CONDUCTORS	TYPE	Shielded, non-leaded cable	
	DIRECTION	From above or below	
	TERMINATION	Provision for 2 terminals per phase (NEMA drilling less terminals) up to 750 MCM (21" allowed for stress cones)	

CT's		Add 2 or 3 wound type phase CT's	
		Add window type phase CT's to bottom bus entrance compartment	
TERMINALS			Add provision for a total of 4 terminals per phase (NEMA drilling less terminals) up to and including 750 MCM (25" allowed for stress cones)
		Add Burndy Hylug terminals per Tables 7-45, 7-46.	
		Add clamp type terminals per Tables 7-45, 7-46.	
POTHEADS		Add 3-1/C or 1-3/C potheads above or below; add 6-1/C or 2-3/C potheads above	
			Add 6-1/C or 2-3/C potheads below
ROOF BUSHINGS (OUTDOOR ONLY)			Add 3 roof bushings (no ground sensor)
METAL-ENCLOSED BUS		Add termination for metal-enclosed bus above or below	

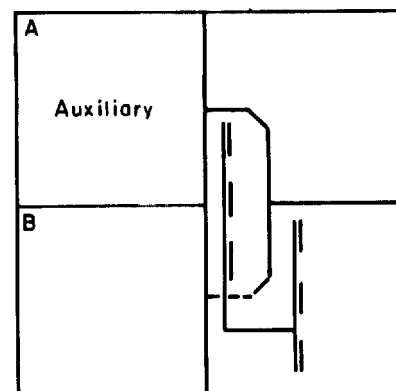
POWER/VAC Switchgear Equipment

Auxiliary in A
Tie Breaker in B



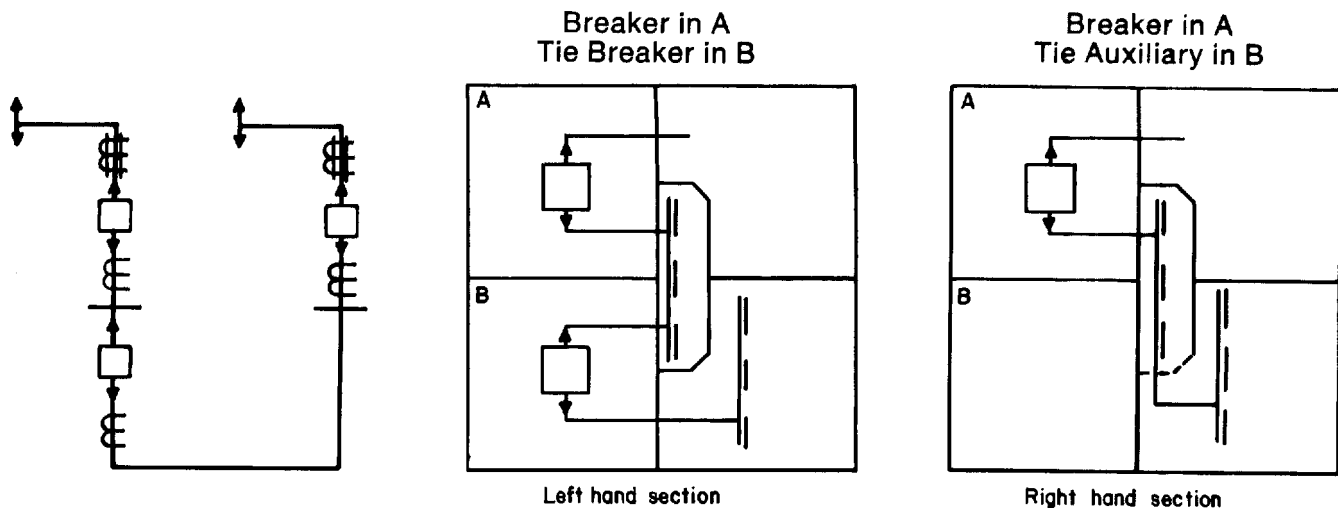
Left hand section

Auxiliary in A
Tie Auxiliary in B



Right hand section

		(NOT AVAILABLE IN 82 IN.)	94 IN. DEEP VERTICAL SECTIONS
RATINGS	BUS	1200, 2000, or 3000 A	
	BREAKERS	1200, 2000, or 3000 A tie	
CT's		Add window type phase CT's to the breaker unit, in breaker compartment	

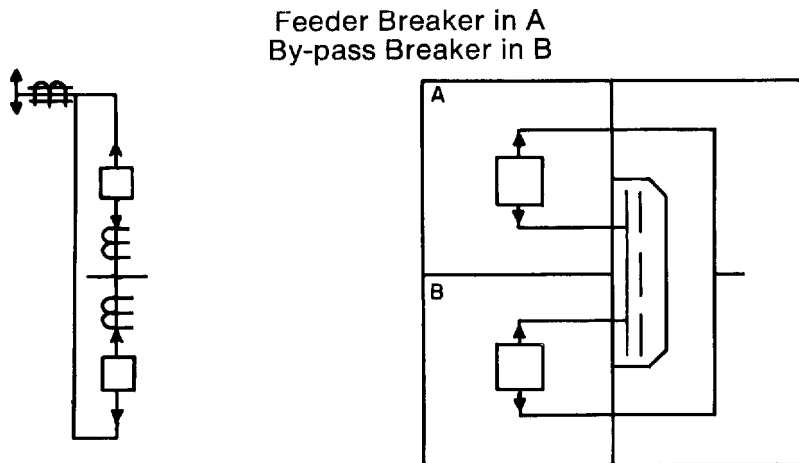


		(NOT AVAILABLE IN 82 IN.)	94 IN. DEEP VERTICAL SECTIONS
RATINGS	BUS	1200, 2000, or 3000 A	
	BREAKERS	1200, 2000, or 3000 A tie; 1200 A over tie for 1200 A or 2000 A tie;	
ENTERING POWER CONDUCTORS	TYPE	Shielded, non-leaded	
	DIRECTION	From above or below	
	TERMI- NATION	Provision for 2 terminals per phase (NEMA drilling less terminals) and up to including 750 MCM (21" allowed for stress cones)	

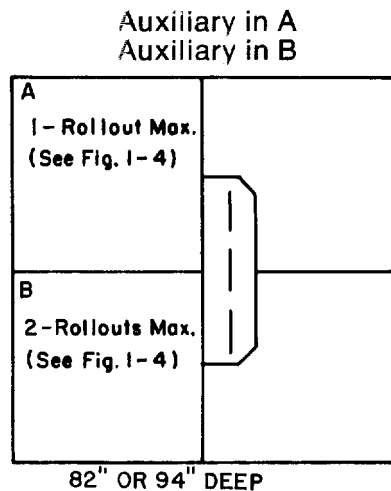
OPTIONS

CT's		Add small ground sensor (7" window)	
		Add large ground sensor (12" window)	
		Add 2 or 3 wound type phase CT's	
		Add window type phase CT's in the breaker unit in breaker compartment	
TERMINALS		Add provision for a total of 4 terminals per phase (NEMA drilling less terminals) up to and including 750 MCM (25" allowed for stress cones)	
		Add Burndy Hylug terminals per Tables 7-45, 7-46.	
		Add clamp type terminals per Tables 7-45, 7-46.	
POTHEADS		Add 3-1/C or 1-3/C potheads above or below; add 6-1/C or 2-3/C potheads above; no ground sensor or wound type CT's	
			Add 6-1/C or 2-3/C potheads below; no ground sensor
ROOF BUSHINGS (OUTDOOR ONLY)		Add 3 roof bushings; no ground sensor	
METAL-ENCLOSED BUS		Add metal-enclosed bus above or below; no ground sensor	

POWER/VAC Switchgear Equipment



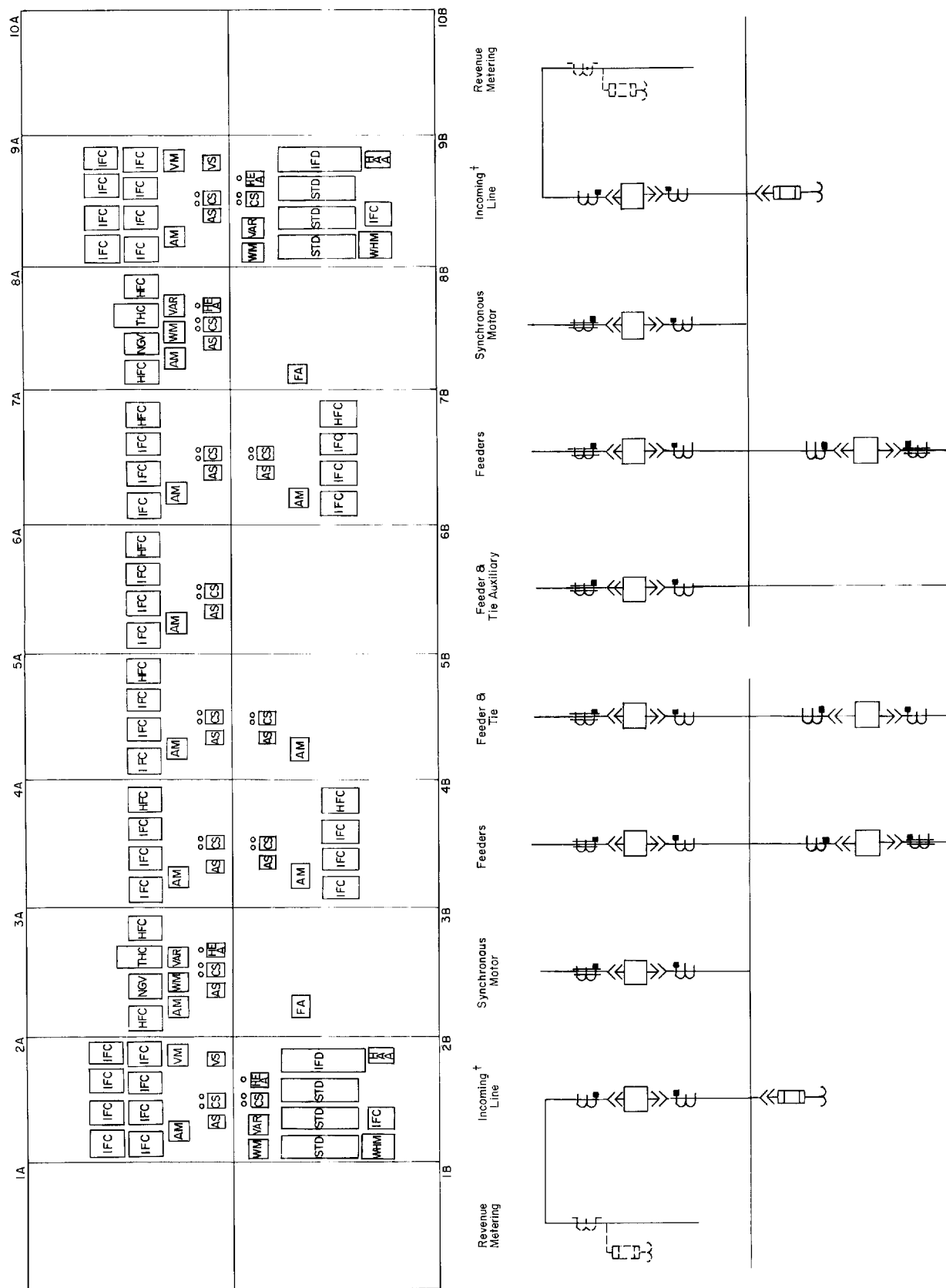
		82 IN. DEEP VERTICAL SECTIONS	94 IN. DEEP VERTICAL SECTIONS
RATINGS	BUS	1200, 2000, or 3000 A	
	BREAKERS	1200 or 2000 A	
ENTERING POWER COMPONENTS	TYPE	Shielded, non-leaded cable	
	DIRECTION	From above or below	
	TERMINATION	Provision for 2 terminals per phase (NEMA drilling less terminals) up to and including 750 MCM for each circuit (21" allowed for stress cones)	
CT's		Add small ground sensor CT (7" window)	
		Add large ground sensor CT (12" window)	
		Add 2 or 3 wound type phase CT's	
TERMINALS		Add provision for total of 4 terminals per phase (NEMA drilling less terminals) up to and including 750 MCM (25" allowed for stress cones)	
		Add Burndy Hylug terminals per Tables 7-45, 7-46.	
		Add clamp type terminals per Tables 7-45, 7-46.	
POTHEADS		Add 1-3/C or 3-1/C potheads. No ground sensor, no wound type CT's	
		Add 2-3/C or 6-1/C potheads. No ground sensor or wound type CT's	
ROOF BUSHINGS (OUTDOOR ONLY)		Add 3 roof bushings, no ground sensor	
METAL-ENCLOSED BUS		Add metal-enclosed bus — no ground sensor	



MAXIMUM PT's PER ROLLOUT	<p>3 — Fused PT's with 1 fuse each, rated 14,400 V or less, connected wye-wye (Unit A or bottom of Unit B)</p> <p style="text-align: center;">or</p> <p>2 — Fused PT's with 2 fuses each rated 14,400 V or less, connected in open delta</p>
MAXIMUM CPT PER ROLLOUT	1 — Single-phase, 2-fuse CPT rated 15 kVA or less, with a non-automatic secondary breaker
MAXIMUM CPT IN REAR COMPARTMENT	1 — 37.5 kVA dry-type, single-phase or 45 kVA dry-type, 3-phase. Bottom rollout used for fuses; second rollout space used for non-automatic stationary secondary breaker.
MAXIMUM FUSE ON ROLLOUT	25E (size C only) fuse in bottom rollout for use with stationary remote mounted control power transformer.
CPT SECONDARY RATINGS	<p>115/230 V single-phase</p> <p>208Y/120 V three-phase</p> <p>480Y/277 V three-phase</p>
CPT kVA RATINGS	<p>Single-phase, dry on rollout: 5, 10, 15 kVA</p> <p>Single-phase, dry: 25, 37½ kVA (only 25 kVA at 2400 V)</p> <p>Three-phase, dry: 30, 45 kVA (only 30 kVA at 2400 V)</p>
CPT CONNECTIONS	Single-phase, CPT's connected from phase 1 to phase 2 or phase 1 to neutral; three-phase CPT's consist of 3 single-phase transformers with delta-connected primaries.

POWER/VAC Switchgear Equipment

Typical
Switchgear Lineup



† This is a custom vertical section, because controls for the 115 kV primary breaker are located on this panel. (See Figure 2-3.)
Figure 6-1. Illustration of sample lineup discussed in Section 2 and documented in Section 11.

[illegible]

DEVICE LIST FOR VERTICAL SECTIONS

Vertical Section	Device	Dev. No.	Qty	Description	Vertical Section	Device	Dev. No.	Qty	Description
1A,B 10A,B	—	—	—	Provision for revenue meter CT's & PT's NEMA drilling for 2 terminals per phase to terminate 500-MCM cable from above		Breaker Closing Fuse Pullout	FU	1	2P-30A (15A Fuses)
						Breaker Tripping Fuse Pullout	FU	1	2P-60A (35A Fuses)
						Ammeter	AM	1	AB-40, 300A Scale (5A, 6A)
									AB-40, 400A Scale (4A, 4B, 7A, 7B)
2A 9A	Power Circuit Breaker	52	1	VB-13.8-500, 1200A		Ammeter Switch	AS	1	16SB1CA15X2
	Phase Overcurrent Relays	51B	3	121FC53A1A		Provision for Feeder Cables	—	1	NEMA Drilling for 1 terminal per phase to terminate 500-MCM cable from above
	Residual Overcurrent Relay	51N/B	1	121FC53A2A					
	Phase Overcurrent Relays	50/51	3	121FC53B1A					
	Residual Overcurrent Relay	51N	1	121FC53B2A					
	Circuit Current Transformers	CT	3	JAG-0 1200/5A	5B,6B	Power Circuit Breaker	52	1	VB-13.8-500, 1200A
	Differential Current Transformers	CT	3	JAG-0 1200/5A		Circuit Current Transformers	CT	6	JAG-0 1200/5A
	Circuit Breaker Control Switch	CS	1	16SB1B9X2		Circuit Breaker Control Switch	CS	1	16SB1B9X2
	Indicating Lights	IL	2	ET-16, 125V (1-R, 1-G)		Indicating Lights	IL	2	ET-16, 125V (1-R, 1-G)
	Ammeter	AM	1	AB-40, 1200A Scale		Breaker Closing Fuse Pullout	FU	1	2P-30A (15A Fuses)
	Ammeter Switch	AS	1	16SB1CA15X2		Breaker Tripping Fuse Pullout	FU	1	2P-60A (35A Fuses)
	Voltmeter	VM	1	AB-40, 18-kV Scale		Ammeter	AM	1	AB-40, 1200A Scale
	Voltmeter Switch	VS	1	16SB1CF11X2		Ammeter Switch	AS	1	16SB1CA15X2
	Breaker Closing Fuse Pullout	FU	1	2P-30A (15A Fuses)					
	Breaker Tripping Fuse Pullout	FU	1	2P-60A (35A Fuses)	3A 8A	Power Circuit Breaker	52	1	VB-13.8-500, 1200A
2B 9B	Transformer Differential Relays	87T	3	12STD15C5A		Phase Overcurrent Relay	49/50	1	12THC30A__A
	Transformer Ground Differential Relay	87TG	1	121FD51D1A		Ground Sensor Relay	50GS	1	12HFC11B1A
	Transformer Fault Pressure Auxiliary Relay	63FPX	1	12HAA16B2		Motor Differential Relay	87M	1	12HFC13B1A
	Hand Reset Lockout Relay	86T	1	12HEA61B237X2		Hand Reset Lockout Relay	86M	1	12HEA61B235X2
	Ground Overcurrent Relay	51G	1	121FC53B2A		Undervoltage Relay	27	1	12NGV13B29A
	Auxiliary Current Transformer	CT	1	JAG-0 5/0.833A		Timer, Agastat	62	1	7022PB, 0.5-5 sec
	Potential Transformers	PT	2	JVM 14,400/120V (2E Fuses)		Circuit Current Transformers	CT	3	JAG-0 300/5A
	Circuit Breaker Control Switch	CS	1	16SB1B9X2		Ground Sensor Current Transformer	CT	1	Tech-Tran 50/5A
	Indicating Lights	IL	3	ET-16, 125V (1-R, 1-W, 1-G)		Wattmeter	WM	1	AB-40, 7000kW Scale
	Wattmeter	WM	1	AB-40, 30MW Scale		Varmeter	VARM	1	AB-40, 3500kVAR Scale
	Varmeter	VARM	1	AB-40, 15MVAR Scale		Ammeter	AM	1	AB-40, 300A Scale
	Watt-hour Meter	WHM	1	DS-63		Ammeter Switch	AS	1	16SB1CA15X2
4A,B 5A,6A 7A,B	Power Circuit Breaker	52	1	VB-13.8-500, 1200A		Circuit Breaker Control Switch	CS	1	16SB1B9X2
	Phase Overcurrent Relays	50/51	3	121FC53B1A		Indicating Lights	IL	3	ET-16, 125V (1-R, 1-W, 1-G)
	Ground Sensor Relay	50GS	1	12HFC11B1A		Breaker Closing Fuse Pullout	FU	1	2P-30A (15A Fuses)
	Circuit Current Transformers	CT	3	JAG-0 300/5A (5A, 6A) 400/5A (4A, 4B, 7A, 7B)		Breaker Tripping Fuse Pullout	FU	1	2P-60A (35A Fuses)
						Provisions for Motor Cables	—	1	NEMA Drilling for 1 terminal per phase to terminate 500-MCM cable from above
	Ground Sensor Current Transformer	CT	1	Tech-Tran 50/5	3B 8B	Field Ammeter and Shunt	FA	1	DB-40 and Shunt
	Circuit Breaker Control Switch	CS	1	16SB1B9X2		Exciter Relay	53	1	IC2820A100BB
	Indicating Lights	IL	2	ET-16, 125V (1-R, 1-G)		Field Contactor	41	1	IC2812
						Resistors	RES	2	Field Discharge and Field Forcing
						Field Application Panel	13,X,Y	1	0114C4063

Section 7

Basic and Optional Device Lists

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Basic and Optional Device Lists

INTRODUCTION

This section contains tabulated device lists of both basic and optional devices included in POWER/VAC metalclad switchgear. Individual model numbers are given, along with their pertinent characteristics. Use these tables when selecting options, as well as when investigating the characteristics of basic items.

Model numbers other than those listed in this section are available as custom items.

All listed devices are 60-Hz unless otherwise noted.

RELAYS

Table 7-1
Overcurrent Relays

Time Current Characteristics	Pickup Current Range		Model No.	Device No.
	Time	Instantaneous		
	(Amperes)			
Inverse	1-12	None	12IFC51A1A	51
	0.5-4	None	12IFC51A2A	51N,51G,51GS
	1-12	6-150	12IFC51B1A	50/51
	0.5-4	2-50	12IFC51B2A	50/51N
Very Inverse	1-12	None	12IFC53A1A	51
	0.5-4	None	12IFC53A2A	51N,51G,51GS
	1-12	6-150	12IFC53B1A	50/51
	1-12	2-50	12IFC53B3A	50/51
	0.5-4	2-50	12IFC53B2A	50/51N
Extremely Inverse	1-12	None	12IFC77A1A	51
	0.5-4	None	12IFC77A2A	51N,51G,51GS
	1-12	6-150	12IFC77B1A	50/51
	1-12	2-50	12IFC77B3A	50/51
	0.5-4	2-50	12IFC77B2A	50/51N
Long Time	2.5-7.5	6-150	12IFC66K1A	26/50/83 or 49/50/83
Inverse-torque Controlled	4-16	None	12IAC60A111A	51R
Instantaneous				
1-Element	None	0.5-4	12HFC11B1A	50GS
2-Element	None	0.5-4	12HFC12B1A	50
2-Element	None	2-50	12HFC12B2A	50
3-Element	None	0.5-4	12HFC13B1A	87M
3-Element	None	2-50	12HFC13B2A	50

Section 7

Table 7-2
Directional Overcurrent Relays
(Voltage rating 120 volts)

Time-current Characteristics	Pickup Current Range		Model No.	Device No.
	Time	Instantaneous		
	(Amperes)			
Inverse	1.5-6	None	12IBC51E2A	67
	4-16	None	12IBC51E101A	67
Very Inverse	1.5-6	None	12IBC53K1A	67
	4-16	None	12IBC53K2A	67
Inverse	1.5-6	None	12BCG51K2A	67N
	0.5-2	None	12BCG51K3A	67N
Very Inverse	1.5-6	None	12BCG53K2A	67N
	0.5-2	None	12BCG53K3A	67N
Very Inverse	1.5-6	20-80	12JBC53K4A	67

Table 7-3
Current-polarized Directional Ground Relays
(Device No. 67N)

Time-current Characteristics	Pickup Current Range		Model No.
	Time	Instantaneous	
	(Amperes)		
Inverse	0.5-2	None	12ICC51A1A
	1-4	None	12ICC51A2A
	1.5-6	None	12ICC51A3A

Table 7-4
Voltage-restrained Overcurrent Relays
(Device No. 51V)

Time-current Characteristics	Pickup Current Range	Voltage Range	Model No.
	(Amperes)	(Volts)	
Inverse	4-16	120	12IJC51A13A
Inverse	4-16	208	12IJC51A9A

Table 7-5
Temperature Relays
(Device No. 49)

Temperature Range Rating	Voltage Range (Volts)	Model No.
80-120C	120	12IRT51C1A
100-160C	120	12IRT53C6A

Table 7-6
Thermal Overcurrent Relay
(Device No. 49/50)

Heater Current (Amperes)	Instantaneous (Amperes)	Model No.
2.63	10-40	12THC30A2A
2.93	10-40	12THC30A3A
3.16	10-40	12THC30A4A
3.58	10-40	12THC30A5A
4.24	20-80	12THC30A6A
4.73	20-80	12THC30A7A

Table 7-7
Differential Relays

Description	Taps (Amperes)	Model No.	Device No.
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TRANSFORMER

48/125/250V dc control, 2-restraint, 0.2/2A target and seal-in, 15/25/40% slope	2.9, 3.2, 3.5, 3.8, 4.2, 4.6, 5.0, 8.7	12STD15C5A	87T
0.5A minimum pickup, 3-restraint, 12.5/25% slope	—	12IFD51D1A	87TG

BUS

150V, 0.2/2A target and seal-in	87L: 75-300V 87H: 2-50A	12PVD21C11A	87B
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MOTORS (6 CT DIFFERENTIAL)

0.2A minimum pickup, 0.2A target and holding coil	—	12CFD22B2A	87M
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Table 7-8
Agastat Timers
(Device No. 62)

Description	Model No.
Time-delay Pickup 48V dc, 0.5-5 sec. 120V dc, 0.5-5 sec. 250V dc, 0.5-5 sec.	7012 NB 7012 PB 7012 SB
Time-delay Dropout 48V dc, 0.5-5 sec. 120V dc, 0.5-5 sec. 250V dc, 0.5-5 sec.	7022 NB 7022 PB 7022 SB

Basic and Optional Device Lists

Table 7-9
Lockout Relay
(Device No. 86)

Contacts		Voltage Rating (Volts)	Model No.
N.O.	N.C.		
3	3	125V dc	12HEA61A223X2
5	5	125V dc	12HEA61B235X2
7	3	125V dc	12HEA61B237X2
13	3	125V dc	12HEA61C243X2
3	3	48V dc	12HEA61A233X2
5	5	48V dc	12HEA61B255X2
7	3	48V dc	12HEA61B257X2
13	3	48V dc	12HEA61C263X2
3	3	250V dc	12HEA61A213X2
5	5	250V dc	12HEA61B215X2
7	3	250V dc	12HEA61B217X2
13	3	250V dc	12HEA61C223X2
3	3	230V ac	12HEA61A303X2
5	5	230V ac	12HEA61B375X2
7	3	230V ac	12HEA61B377X2
13	3	230V ac	12HEA61C363X2

Table 7-10
Target Relays
(Device No. 63FPX)

Description	Model No.
48V dc, Seal-in	12HAA16B1F
125V dc, Seal-in	12HAA16B2F
250V dc, Seal-in	12HAA16B3F

Table 7-11
Auxiliary Relay
(Device No. 27X, 62X, X)

Description	Model No.
250V dc	12HGA11W51
125V dc	12HGA11W52
48V dc	12HGA11W54
115V ac	12HGA11W70
230V ac	12HGA11W71
250V dc	12HFA51A41
125V dc	12HFA51A42
48V dc	12HFA51A44

Table 7-12
Undervoltage Relays
(Device No. 27)

Description	Model No.
120V ac, 2A Target (Instantaneous)	12NGV13B29A
(Device No. 47)	
Undervoltage Phase Sequence	12ICR53A1A

Table 7-13
Power Directional Relays
(Device No. 32)

Description (5A, 115V)				Model No.
Target Coil	Holding Coil		Pickup	
	Right	Left		
	(Amperes)			
1.0	1.0	No	0.004	12CCP13D1A
0.2	No	No	0.004	12CCP13D10A
1.0	No	No	0.004	12CCP13D15A
Voltage Range (Volts)		Power Range (Watts)		Model No.
120		25-100		12ICW51A2A
208		50-200		12ICW51A11A

Table 7-14
Loss of Excitation Relay
(Device No. 40)

Description	Model No.
5A-115V ac 125/250V dc, Control	12CEH51A1A

Table 7-15
Voltage Unbalance Relay
(Negative-phase Sequence)
(Single Phase — Blown Fuse Protection)
(Device No. 60)

Rating and Description	Model No.
120V ac, No Target	12NBV11A1A
208V ac, No Target	12NBV11A3A

Table 7-16
Voltage Unbalance Relay
(Blown PT Fuse Protection)
(Device No. 60V)

Rating and Description	Model No.
120V ac	12CFVB11B1A

Table 7-17
Current Balance Relay
(Device No. 60C)

Rating and Description	Model No.
7A	12IJC51A3A

Table 7-18
Reclosing Relay
(Device No. 79)

Reclosing Cycle	Control Voltage	Model No.
To be set by user. (One instantaneous and 3 time-delay reclosures maximum)	48/125V dc 240V ac	12NLR21M1A 12NLR21D2A

Table 7-19
Reclosing Cut-off (Cutler-Hammer) Switch
(Device No. 79CO)

Type	Description	Model No.
JBT	DPST with locking ring	ST50K

Table 7-20
Underfrequency Relays
(Device No. 81)

Description	Model No.
54.2 Hz min – 60.8 Hz max; 120V; 0.07-1.33 seconds time delay	12SFF23H1A

INSTRUMENTS

Table 7-21
Type AB-40 Ammeters
(5-ampere movement, 40-70 Hz)

Scale (Amperes)	Model No.
100	50103131 LS PK2
150	50103131 LS PZ2
200	50103131 LS RL2
250	50103131 LS RS2
300	50103131 LS RX2
400	50103131 LS SC2
500	50103131 LS SF2
600	50103131 LS SJ2
800	50103131 LS SN2
1000	50103131 LS SS2
1200	50103131 LS SV2
1500	50103131 LS TC2
2000	50103131 LS TM2
2500	50103131 LS TV2
3000	50103131 LS UA2
4000	50103131 LS UE2

Table 7-22
Type AB-40 Voltmeters
(150-volt movement, 40-70 Hz)

Scale	Model No.
3000V	50103021 PZ UA2
5250V	50103021 PZ UL2
6000V	50103021 PZ UP2
9000V	50103021 PZ UY2
10.5kV	50103021 PZ WM2JCU
15kV	50103021 PZ WZ2
18kV	50103021 PZ XE2

Basic and Optional Device Lists

Table 7-23
Type AB-40 Wattmeters
(5A, 120V, 50/60 Hz)

Wattmeter scales are determined by current transformer and potential transformer ratios. (CT ratio x PT ratio = TR). Catalog number of the instrument is a root number plus a suffix for the scale.

TR	Scale kW	Suffix
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3-PHASE, 3-WIRE

Root number for zero left

scales = 50-103221A

100	100	RBU1CAC
120	120	RBU1CCC
160	150	XAG1CEC
175	175	RBU1GGC
200	200	RBU1CGC
210	200	XGJ1CGC
240	250	RDR1CJC
280	300	RET1CKC
300	300	RBU1CKC
320	320	RBU1CLC
350	350	RBU1CMC
360	350	RAS1CMC
400	400	RBU1CNC
480	500	RDR1CRC
500	500	RBU1CRC
525	500	XGJ1CRC
600	600	RBU1CTC
700	700	RBU1CWC
720	700	RAS1CWC
800	800	RBU1CYC
900	900	RBU1CZC
960	1000	RDR1DAC
1000	1000	RBU1DAC
1050	1000	XGJ1DAC
1200	1200	RBU1DCC
1400	1400	RBU1DDC
1500	1500	RBU1DEC
1600	1500	XAG1DEC
1750	1750	RBU1HGC
1800	1800	RBU1DFC
2000	2000	RBU1DGC
2100	2000	XGJ1DGC
2400	2500	RDR1DJC
2800	3000	RET1DKC
3000	3000	RBU1DKC
3200	3000	XAG1DKC
3500	3500	RBU1DMC
3600	3500	RAS1DMC
4000	4000	RBU1DNC
4200	4000	XGJ1DNC
4800	5000	RDR1DRC

TR	Scale kW	Suffix
5000	5000	RBU1DRC
5600	6000	RET1DTC
6000	6000	RBU1DTC
6400	6500	RCP1DUC
7000	7000	RBU1DWC
7200	7000	RAS1DWC
8000	8000	RBU1DYC
8400	8000	XGJ1DYC
	Scale MW	
9600	10MW	RDR1BAD
10000	10MW	RBU1BAD
10500	10MW	XGJ1BAD
11200	12	RET1BCD
12000	12	RBU1BCD
12800	12.5	RAU1FCD
14000	15	RET1BED
14400	15	RDR1BED
16000	16	RBU1FED
17500	17.5	RBU1FGD
18000	18	RBU1BFD
19200	20	RDR1BGD
20000	20	RBU1BGD
21000	20	XGJ1BGD
24000	25	RDR1BJD
28000	28	RBU1FKD
28800	30	RDR1BKD
30000	30	RBU1BKD
32000	32	RBU1BLD
36000	35	RAS1BMD
38400	40	RDR1BND
40000	40	RBU1BND
48000	50	RDR1BRD
50000	50	RBU1BRD
60000	60	RBU1BTD
72000	70	RAS1BWD
80000	80	RBU1BYD
96000	100	RDR1CAD

Table 7-23 (Cont'd)

TR	Scale kW	Suffix	TR	Scale MW	Suffix
3-PHASE, 4-WIRE			4800	10	RDR1BAD
Root number for zero left			5600	12	RET1BCD
scales: 50-103251A					
100	200	RBU1CGC	6000	12	RBU1BCD
120	240	RBU1CHC	6400	12.5	RAS1FCD
160	300	XAG1CKC	7000	14	RBU1BDD
200	400	RBU1CNC	7200	14	RAS1BDD
240	450	XAG1CPC	8000	16	RBU1FED
300	600	RBU1CTC	8400	17.5	RDR1FGD
320	600	XAG1CTC	9600	20	RDR1BGD
350	700	RBU1CWC	10000	20	RBU1BGD
360	700	RAS1CWC	11200	24	RET1BHD
400	800	RBU1CYC	12000	25	RDR1BJD
420	800	XGJ1CYC	12800	25	RAU1BJD
480	1000	RDR1DAC	14000	28	RBU1FKD
560	1200	RET1DCC	14400	30	RDR1BKD
600	1200	RBU1DCC	16000	30	XAG1BKD
700	1400	RBU1DDC	16800	35	RDR1BMD
800	1600	RBU1HEC	18000	35	RAS1BMD
900	1800	RBU1DFC	19200	40	RDR1BND
1000	2000	RBU1DGC	20000	40	RBU1BND
1050	2000	XGJ1DGC	21000	40	XGJ1BND
1200	2500	RDR1DJC	22400	45	RBX1BPD
1400	3000	RET1DKC	24000	50	RDR1BRD
1600	3000	XAG1DKC	28000	55	RAX1BSD
1800	3500	RAS1DMC	30000	60	RBU1BTD
2000	4000	RBU1DNC	32000	60	XAG1BTD
2100	4000	XGJ1DNC	35000	70	RBU1BWD
2400	4500	XAG1DPC	36000	70	RAS1BWD
2800	5500	RAX1DSC	42000	80	XCJ1BYD
3000	6000	RBU1DTC	48000	90	XAG1BZD
3200	6000	XAG1DTC			
3500	7000	RBU1DWC			
3600	7000	RAS1DWC			
4000	8000	RBU1DYC			
4200	8000	XGJ1DYC			

Basic and Optional Device Lists

Table 7-24
Type AB-40 Varmeters
(5A, 50/60 Hz)

Varmeter scales are determined by current transformer and potential transformer ratios. (CT ratio x PT ratio = TR). Catalog number of the instrument is a root number plus a suffix for the scale. Scales are zero center: "in" at left, "out" at right. Cross-phase connections used.

TR	Scale kvar	Suffix	TR	Scale kvar	Suffix
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Three-phase, three-wire, cross-phase, three current coils on open-delta potential transformers.

Coil rating 5 ampere, 120 volt, 50/60 Hz, connections 2634K26.

Root number = 50-103742A.

100	50	JLE1BRC	4800	2500	JUK1DJC
120	60	JLE1BTC	5000	2500	JLE1DJC
160	80	JLE1BYC	5600	3000	KPD1DKC
175	90	JSG1BZC	6000	3000	JLE1DKC
200	100	JLE1CAC	6400	3000	GXB1DKC
210	100	HMJ1CAC	7000	3500	JLE1DMC
240	120	JLE1CCC	7200	3500	HSE1DMC
280	150	KPD1CEC	8000	4000	JLE1DNC
300	150	JLE1CEC	8400	4000	HMJ1DNC
320	160	JLE1GEC	9600	5000	JUK1DRC
350	175	JLE1GGC	10000	5000	JLE1DRC
360	175	HSE1GGC	10500	5000	HMJ1DRC
400	200	JLE1CGC	11200	5500	HUC1DSC
480	250	JUK1CJC	12000	6000	JLE1DTC
500	250	JLE1CJC	12800	6000	GXB1DTC
525	250	HMJ1CJC	14000	7000	JLE1DWC
600	300	JLE1CKC	14400	7000	HSE1DWC
700	350	JLE1CMC	16000	8000	JLE1DYC
720	350	HSE1CMC	17500	9000	JSG1DZC
800	400	JLE1CNC	18000	9000	JLE1DZC
900	450	JLE1CPC			
960	500	JUK1CRC			
1000	500	JLE1CRC			
1050	500	HMJ1CRC			
1200	600	JLE1CTC			
1400	700	JLE1CWC			
1500	750	JLE1CXC			
1600	800	JLE1CYC			
1750	900	JSG1CZC			
1800	900	JLE1CZC			
2000	1000	JLE1DAC			
2100	1000	HMJ1DAC			
2400	1200	JLE1DCC			
2800	1400	JLE1DDC			
3000	1500	JLE1DEC			
3200	1600	JLE1HEC			
3500	1750	JLE1HGC			
3600	1750	HSE1HGC			
4000	2000	JLE1DGC			
4200	2000	HMJ1DGC			
			TR	Scale Mvar	Suffix
			19200	10	JUK1BAD
			20000	10	JLE1BAD
			21000	10	HMJ1BAD
			24000	12	JLE1BCD
			28000	14	JLE1BDD
			28800	15	JUK1BED
			30000	15	JLE1BED
			32000	16	JLE1FED
			36000	17.5	HSE1FGD
			38400	18	GXB1BFD
			40000	20	JLE1BGD
			48000	25	JUK1BJD
			50000	25	JLE1BJD
			60000	30	JLE1BKD
			72000	35	HSE1BMD
			80000	40	JLE1BND
			96000	50	JUK1BRD

TR	Scale kvar	Suffix	TR	Scale kvar	Suffix
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Three-phase, four-wire, cross-phased,

Wye-wye potential transformers, 208-volt potential coils

Root number = 50-103742B

100	100	AWN1CAC	4800	5000	BTX1DRC
120	120	AWN1CCC	5600	5500	ARS1DSC
160	160	AWN1GEC	6000	6000	AWN1DTC
200	200	AWN1CGC	6400	6500	BMR1DUC
240	250	BTX1CJC	7000	7000	AWN1DWC
300	300	AWN1CKC	7200	7000	ANR1DWC
320	300	KSC1CKC	8000	8000	AWN1DYC
350	350	AWN1CMC	8400	8000	KWD1DYC
360	350	ANR1CMC			
400	400	AWN1CNC			
420	400	KWD1CNC			
480	500	BTX1CRC			
560	600	CPL1CTC			
600	600	AWN1CTC			
700	700	AWN1CWC			
800	800	AWN1CYC			
900	900	AWN1CZC			
1000	1000	AWN1DAC			
1050	1000	KWD1DAC			
1200	1200	AWN1DCC			
1400	1400	AWN1DDC			
1600	1600	AWN1HEC			
1800	1800	AWN1DFC			
2000	2000	AWN1DGC			
2100	2000	KWD1DGC			
2400	2500	BTX1DJC			
2800	3000	CPL1DKC			
3000	3000	AWN1DKC			
3200	3000	KSC1DKC			
3500	3500	AWN1DMC			
3600	3500	ANR1DMC			
4000	4000	AWN1DNC			
4200	4000	KWD1DNC			
			TR	Scale Mvar	Suffix
			9600	10	BTX1BAD
			10000	10	AWN1BAD
			11200	12	CPL1BCD
			12000	12	AWN1BCD
			12800	12	KSC1BCD
			14000	14	AWN1BDD
			14400	14	ANR1BDD
			16000	16	AWN1FED
			16800	17.5	BTX1FGD
			18000	18	AWN1BFD
			19200	20	BTX1BGD
			20000	20	AWN1BGD
			21000	20	KWD1BGD
			22400	24	CPL1BHD
			24000	24	AWN1BHD
			28000	30	CPL1BKD
			30000	30	AWN1BKD
			32000	30	KSC1BKD
			35000	35	AWN1BMD
			36000	35	ANR1BMD
			42000	42	KWD1BMD
			48000	50	BTX1BRD

Table 7-25
Type DB-40 Temperature Meter

Rating	Model No.
20-140C, 120V 50/60 Hz (One way lead resistance 0.21-0.40 ohm)	50103502CAAB2

Table 7-27
Type AB-40 Frequency Meter

Description	Model No.
120V — 55-65 Hz scale	50-103372-ANAN

Table 7-26
Type SB-1 Temperature Meter Switch

Stage	Description	Model No.
4	3 RTD's and test position, 2-wire RTD connection	16SB1CE28X2

Table 7-28
Type AB-16 Synchroscope

Description	Model No.
120V	50-120452-AAAA

METERS

Table 7-29
Watthour and Watthour Demand Meters
(120V, 2.5A) Secondary Reading
(Multiplier Specified on Nameplate)

Description	Type	Demand Interval	Model No.
3-phase, 3-wire, 2-element, watthour	DS63	—	701X90G008
3-phase, 3-wire, 2-element, watthour demand	DSM63	15 min.	701X91G007

Table 7-30
Type KT Time Meter

Description	Model No.
120V ac, Register (in hrs.)	50240711AAAD1

Basic and Optional Device Lists

SWITCHES

Table 7-31
Control Switches

Description	Stages	Positions	Model No.
Type SB-1			
Circuit Breaker Control or Permissive Governor Switch	3	(C) (NAC) (NAT) (T)	16SB1B9X2
	2	(RAISE) (LOWER)	16SB1BA339SSS2R
Type SB-12		Catalog No.	
Breaker	3		006353570G002
Position Switch	6		006353570G001
Stationary	3		006353570G002
Auxiliary Switch	6		006353570G001
	10		006353570G012

Table 7-32
Type SB-1 Transfer Switches

Description	Stages	Positions	Model No.
Ammeter Switch (Middle of Circuit)	6	(1)(OFF)(2) (OFF)(3)	16SB1CA15X2
Voltmeter Switch (3-phase, 3-wire)	2	(OFF)(1-2) (2-3)(3-1)	16SB1CF11X2
Voltmeter Switch (3-phase, 4-wire)	4	(OFF)(1-2) (2-3)(3-1) (1)(2)(3)	16SB1CF16X2
Voltmeter Switch (Removable Handle)	2	(OFF)(1-2) (2-3)(3-1)	16SB1CF15X2
Synchronizing Switch (Removable Handle)	3	(OFF)(ON)	16SB1CB201SDM2Y

CURRENT TRANSFORMERS

Table 7-33
Type JAG-0 Window-type
Phase Current Transformers

Ratio	Model No.	Accuracy Class	Saturation Curve
150:5	750X10G501	C20	H-9689241-806
200:5	750X10G502	C20	H-9689241-806
250:5	750X10G503	—	H-9689241-806
300:5	750X10G504	C20	H-9689241-806
400:5	750X10G505	C50	H-9689241-807
500:5	750X10G506	C50	H-9689241-807
600:5	750X10G507	C50	H-9689241-807
800:5	750X10G508	C50	H-9689241-807
1000:5	750X10G509	C100	H-9689241-807
1200:5	750X10G510	C100	H-9689241-807
1500:5	750X10G511	C100	H-9689241-807
2000:5	750X10G512	C100	H-9689241-808
2500:5	750X10G513	C200	H-9689241-809
3000:5	750X10G514	C200	H-9689241-808
3000:3.75	750X10G515	C200	H-9689241-810

Table 7-34
Ground-sensor Current Transformers

Type	Ratio	Window Size	Model No.	Saturation Curve
Tech-Tran	50:5	7-1/8 inches	15371	15371-6
JCG-0	50:5	12 inches	848X67	H-9689241-468

Table 7-35
Type JKS-5 Wound Primary Current Transformers
(15kV Single Secondary)

Ratio	Catalog No.	Accuracy Class Metering			Relaying	Saturation Curve
		B=0.1	B=0.5	B=2.0		
50:5	639X86	0.6	2.4	—	T10	C-5453777
75:5	639X87	0.6	1.2	—	T20	C-5453777
100:5	639X88	0.3	0.6	2.4	T20	C-5453777
150:5	639X89	0.3	0.3	1.2	T50	C-5453777
200:5	639X90	0.3	0.3	1.2	T50	C-5453777
300:5	639X91	0.3	0.3	1.2	T50	C-5453777
400:5	639X92	0.3	0.3	0.3	T100	C-5453777
600:5	639X93	0.3	0.3	0.3	T100	C-5453777

NOTE: — Window-type current transformers are preferred, since wound-type transformers are more expensive and require more space.

— Wound-type current transformers are used when better accuracy (than offered by JAG-0 current transformers) is required for metering.

Table 7-36
Type JKM-0 Auxiliary
Current Transformers

NOTE: 5A winding connected in residual circuit for ground differential relay.

Ratio	Catalog No.	Relaying Accuracy Class	Saturation Curve
10:5	750X41G1	T-50	H-9689241-554
15:5	750X41G2	T-50	H-9689241-554
20:5	750X41G3	T-50	H-9689241-554
25:5	750X41G4	T-50	H-9689241-554
30:5	750X41G5	T-50	H-9689241-554
50:5	750X41G7	T-50	H-9689241-554
75:5	750X41G8	T-50	H-9689241-554
100:5	750X41G9	T-50	H-9689241-554

Basic and Optional Device Lists

POTENTIAL TRANSFORMERS

Table 7-37
Potential Transformers (Line-to-Line)

Type	Rating	Ratio	BIL	Model No.
JVM-3	2400V-200VA	20:1	60	763X21 G41
JVM-3	4200V-200VA	35:1	60	643X94
JVM-5	4800V-400VA	40:1	95	827X79
JVM-5	7200V-400VA	60:1	95	685X37
JVM-5	8400V-400VA	70:1	95	685X39
JVM-5	12000V-400VA	100:1	95	685X40
JVM-5	14400V-400VA	120:1	95	685X41

Table 7-38
Potential Transformers (Line-to-Ground)

Type	Rating		System kV	Ratio	BIL	Model No.
	V	VA				
JVM-3	2400	50	2.4	20:1	60	763X21G43
	2400	200	2.4	20:1	60	643X88
	2400	200	4.16	20:1	60	643X88
	4200	50	4.2	35:1	60	643X93
JVM-5	4800	200	4.8	40:1	110	845X81
	7200	200	7.2	60:1	110	670X42
	8400	200	8.4	70:1	110	670X44
	12000	200	12.0	100:1	110	670X45
	14400	200	14.4	120:1	110	670X46
	4800	400	8.3	40:1	110	765X21G703
	7200	400	12.5	60:1	110	670X43
	8400	400	14.4	70:1	110	670X44

CONTROL POWER TRANSFORMERS

Table 7-39
Control Power Transformers

kVA	Volts		Primary Taps %	BIL kV	Model No. 9T28-
	Primary	Secondary			
5	2400	120/240	1 ± 7½	60	Y5600
	4160	120/240	1 ± 7½	60	Y5601
	4800	120/240	1 ± 7½	95	Y1040G20
	7200	120/240	1 ± 7½	95	Y1040G21
	8400	120/240	1 ± 7½	95	Y1040G22
	12000	120/240	1 ± 7½	95	Y5604
	13300	120/240	1 ± 7½	95	Y5605
10	2400	120/240	1 ± 7½	60	Y5610
	4160	120/240	1 ± 7½	60	Y5611
	4800	120/240	1 ± 7½	95	Y1041G20
	7200	120/240	1 ± 7½	95	Y1041G21
	8400	120/240	1 ± 7½	95	Y1041G22
	12000	120/240	1 ± 7½	95	Y5614
	13300	120/240	1 ± 7½	95	Y5615
15	2400	120/240	1 ± 7½	60	Y5620
	4160	120/240	1 ± 7½	60	Y5621
	4800	120/240	1 ± 7½	95	Y1042G20
	7200	120/240	1 ± 7½	95	Y1042G21
	8400	120/240	1 ± 7½	95	Y1042G22
	12000	120/240	1 ± 7½	95	Y5624
	13300	120/240	1 ± 7½	95	Y5625
25	2400	120/240	1 ± 7½	60	Y5430
	4160	120/240	1 ± 7½	60	Y5431
	4800	120/240	1 ± 7½	95	Y1242G20
	7200	120/240	1 ± 7½	95	Y1242G21
	8400	120/240	1 ± 7½	95	Y1242G22
	12000	120/240	1 ± 7½	95	Y5434
	13300	120/240	1 ± 7½	95	Y5435
37.5	4160	120/240	1 ± 7½	60	Y1223G2
	7200	120/240	1 ± 7½	95	Y1233
	12000	120/240	1 ± 7½	95	Y1243G14
	13200	120/240	1 ± 7½	95	Y1243G3

FUSES

Table 7-40
Type EJ-1 Fuses
For Potential Transformer

Description	Model No.
2400V-1E	9F60AAB001
2400V-2E	9F60BBB002
4800V-0.5E	9F60BBD905
4800V-2E	9F60BBD002
4800V-2E	9F60BDD002
7200V-0.5E	9F60BDE905
7200V-1E	9F60BDE001
14400V-0.5E	9F60BHH905
14400V-1E	9F60BHH001
14400V-2E	9F60BHH002

Table 7-41
Pull-out Control Fuse Blocks

Description (Two-pole)	Catalog No.
30A	0673D0515 421 G01
60A	0673D0515 422 G01

Table 7-42
Type EJ-1 Fuses For
Control Power Transformer Primary

kVA	Voltage Rating (Volts)	Fuse Rating	Model No.
5	2400	7E	9F60DJB007
	4160	5E	9F60DJD005
	4800	5E	9F60DJD005
	7200	3E	9F60DJE003
	8400	3E	9F60DJE003
	12000	2E	9F60DMH002
10	13300	2E	9F60DMH002
	2400	15E	9F60DJB015
	4160	7E	9F60DJD007
	4800	7E	9F60DJD007
	7200	5E	9F60DJE003
	8400	5E	9F60DJE003
15	12000	3E	9F60DMH003
	13300	3E	9F60DMH003
	2400	15E	9F60DJB015
	4160	10E	9F60DJD010
	4800	10E	9F60DJD010
	7200	7E	9F60DJE007
25	8400	7E	9F60DJE007
	12000	5E	9F60DMH005
	13300	5E	9F60DMH005
	2400	25E	9F60DJB025
	4160	15E	9F60DJD015
	4800	15E	9F60DJD015
37.5	7200	10E	9F60DJE010
	8400	10E	9F60DJE010
	12000	7E	9F60DMH007
	13300	7E	9F60DMH007
	4160	25E	9F60DJD025
	7200	15E	9F60DJE015
	1200	10E	9F60DMH010
	13200	10E	9F60DMH010

TEST BLOCKS AND INDICATING LAMPS

Table 7-43
Type PK-2 Test Blocks and Plug

Description	Pole	Model No.
Current Block	4	0133C8576 G006*
Voltage Block	4	0133C8576 G001
Plug	4	006129533 G001

*Through-type Block

Table 7-44
Type ET-16 Indicating Lights

Rating		Color
Volts	Ohms	
48	200	Available in all colors listed below
125	2000	
250	5100	
120	1900	
240	4800	
Available in all ratings listed above		Red Green White Clear Amber

Basic and Optional Device Lists

TERMINATIONS

Table 7-45
Terminals For Copper Cable

Preferred Type Clamp (Screw) Type-Burndy	
Cable Size	Catalog No.
No. 4 Stranded	QA1C-BSV
1/0 AWG	QA26-BSV
3/0 AWG	QA28-BSV
250 MCM	QA31-BSV
400 MCM	QA34-BSV
600 MCM	QA40-2NSV
850 MCM	QA44-2NSV
Optional Type Crimp Type-Burndy	
Cable Size	Catalog No.
1/0 AWG	YA252NSV
2/0 AWG	YA262NSV
3/0 AWG	YA272NSV
4/0 AWG	YA282NSV
250 MCM	YA292NSV
300 MCM	YA302NSV
350 MCM	YA312NSV
500 MCM	YA342NSV
750 MCM	YA392NSV
1000 MCM	YA442NSV

Table 7-46
Terminals For Aluminum Cable

Preferred Type Crimp Type-Burndy Hylugs	
Cable Size	Catalog No.
1/0 AWG	YA25A2NTN
2/0 AWG	YA26A2NTN
3/0 AWG	YA27A2NTN
4/0 AWG	YA28A2NTN
250 MCM	YA29A2NTN
300 MCM	YA30A2NTN
350 MCM	YA31A2NTN
500 MCM	YA34A2NTN
750 MCM	YA39A2NTN
1000 MCM	YA44A2NTN
Optional Type Clamp (Screw) Type-Burndy	
Cable Size	Catalog No.
No. 4-1/0 AWG	NAR25A-2NTN
1/0 AWG-250 MCM	NAR29A-2NTN
250-400 MCM	NAR32A-2NTN
350-600 MCM	NAR36A-2NTN
600-900 MCM	NAR42A-2NTN
900-1250 MCM	NAR45A-2NTN
1250-1600 MCM	NAR46A-2NTN
1500-2000 MCM	NAR48A-2NTN

Table 7-47

**Pothheads For Single-conductor Aluminum Cable
(15 kV)**

Type: Rusgreen

Description	Catalog No.
250 MCM (with wiping sleeve)	X54271SUV-LH-M
500 MCM (with wiping sleeve)	X64571SUV-LH-M
750 MCM (with wiping sleeve)	X64771SU-LH-M
1000 MCM (with wiping sleeve)	X64871SU-LH-M
1500 MCM (with wiping sleeve)	X65971SU-LH-M
2000 MCM (with wiping sleeve)	X65X71SU-LH-M
250 MCM (with no entrance fitting)	54271SUV-LH-M
500 MCM (with no entrance fitting)	64571SUV-LH-M
750 MCM (with no entrance fitting)	64771SU-LH-M
1000 MCM (with no entrance fitting)	64871SU-LH-M
1500 MCM (with no entrance fitting)	65971SU-LH-M
2000 MCM (with no entrance fitting)	65X71SU-LH-M

**For Single-conductor Copper Cable
(15 kV)**

Type: Rusgreen

Description	Catalog No.
250 MCM (with wiping sleeve)	X54271SUV-LH
500 MCM (with wiping sleeve)	X64571SUV-LH
750 MCM (with wiping sleeve)	X64771SU-LH
1000 MCM (with wiping sleeve)	X64871SU-LH
1500 MCM (with wiping sleeve)	X65971SU-LH
2000 MCM (with wiping sleeve)	X65X71SU-LH
250 MCM (with no entrance fitting)	54271SUV-LH
500 MCM (with no entrance fitting)	64571SUV-LH
750 MCM (with no entrance fitting)	64771SU-LH
1000 MCM (with no entrance fitting)	64871SU-LH
1500 MCM (with no entrance fitting)	65971SU-LH
2000 MCM (with no entrance fitting)	65X71SU-LH

**For Three-conductor Aluminum Cable
(15 kV)**

Type: Rusgreen

Description	Catalog No.
250 MCM	0152C5409G021
500 MCM	0152C5409G022
750 MCM	0152C5409G023
1000 MCM	0152C5409G024

**For Three-conductor Copper Cable
(15 kV)**

Type: Rusgreen

Description	Catalog No.
250 MCM	0152C5409G017
500 MCM	0152C5409G018
750 MCM	0152C5409G019
1000 MCM	0152C5409G020

Table 7-48

Stuffing Boxes For Pothheads

Type: Rusgreen

Outside Diameter (Inches)	Base Size	Catalog No.
1.94	4	RSQ-4-OD1.94
2.00	4	RSQ-4-OD2.00
2.06	4	RSQ-4-OD2.06
2.13	4	RSQ-4-OD2.13
2.19	4	RSQ-4-OD2.19
2.25	4	RSQ-4-OD2.25
2.31	4	RSQ-4-OD2.31
2.38	4	RSQ-4-OD2.38
2.44	4	RSQ-4-OD2.44
2.50	4	RSQ-4-OD2.50
2.56	4	RSQ-4-OD2.56
2.62	4	RSQ-4-OD2.62
2.69	4	RSQ-4-OD2.69
2.75	4	RSQ-4-OD2.75
2.81	4	RSQ-4-OD2.81
2.88	4	RSQ-4-OD2.88
2.94	5	RSQ-5-OD2.94
3.00	5	RSQ-5-OD3.00
3.06	5	RSQ-5-OD3.06
3.13	5	RSQ-5-OD3.13
3.19	5	RSQ-5-OD3.19
3.25	5	RSQ-5-OD3.25
3.31	5	RSQ-5-OD3.31
3.38	5	RSQ-5-OD3.38
3.44	5	RSQ-5-OD3.44
3.50	5	RSQ-5-OD3.50
3.56	5	RSQ-5-OD3.56
3.62	5	RSQ-5-OD3.62
3.69	5	RSQ-5-OD3.69
3.75	5	RSQ-5-OD3.75
3.81	5	RSQ-5-OD3.81
3.88	5	RSQ-5-OD3.88

Basic and Optional Device Lists

Table 7-51
PLM Fittings For Potheads

Pothead Description	Outside Diameter (Inches)		Catalog No.
	Min.	Max.	
Single conductor	1.38	1.56	ACS16F4
Single conductor	1.57	1.75	ACS18F4
Single conductor	1.76	1.94	ACS20F4
Single conductor	1.95	2.13	ACS22F4
Single conductor	2.14	2.32	ACS24F4
Single conductor	2.33	2.51	ACS26F4
Single conductor	2.52	2.70	ACS28F4
Single conductor (B/S 5)	2.71	2.90	ACS30F5
Single conductor (B/S 5)	2.91	3.09	ACS32F5
Single conductor (B/S 5)	3.10	3.28	ACS34F5
Single conductor (B/S 5)	3.29	3.47	ACS36F5
Single conductor (B/S 5)	3.48	3.66	ACS38F5
Single conductor (B/S 5)	3.67	3.85	ACS40F5
Three conductor	1.38	1.56	ACS16F
Three conductor	1.57	1.75	ACS18F
Three conductor	1.76	1.94	ACS20F
Three conductor	1.95	2.13	ACS22F
Three conductor	2.14	2.32	ACS24F
Three conductor	2.33	2.51	ACS26F
Three conductor	2.52	2.70	ACS28F
Three conductor	2.71	2.90	ACS30F
Three conductor	2.91	3.09	ACS32F
Three conductor	3.10	3.28	ACS34F
Three conductor	3.29	3.47	ACS36F
Three conductor	3.48	3.66	ACS38F
Three conductor	3.67	3.85	ACS40F

Table 7-49
Wiping Sleeves For Potheads

Type: Rusgreen

Description	Catalog No.
Base Size 4	WS-4
Base Size 4	WS-5

Table 7-50
Adapters For Potheads

Description	Base Size	Catalog No.
Three conductor	4	006273645P001
Three conductor	5	006216909P001
Single conductor	5	0722D0350P016

SURGE ARRESTERS

Table 7-52
Surge Arresters

Arrester Type and Rating	System Nominal kV and grounding		Catalog No.	Arrester Type and Rating	System Nominal kV and grounding		Catalog No.
	Solid Gnd	Ungrounded			Solid Gnd	Ungrounded	
Distribution Type ¹				Line Type			
3 kV L/G	4.16 kV	2.4 kV	9L28AGK173	3 kV L/G	4.16 kV	2.4 kV	9L12HAC003
4.5 kV L/G	4.8 kV	4.16 kV	9L28AGK673	6 kV L/G	6.9 kV	4.8 kV	9L12HAC006
6 kV L/G	6.9 kV	4.8 kV	9L28AGK273	9 kV L/G	12.47 kV	6.9 kV	9L12HAC009
7.5 kV L/G		6.9 kV	9L28AGK773	12 kV L/G	13.8 kV	11.5 kV	9L12HAC012
9 kV L/G	12.47 kV	6.9 kV	9L28AGK372	15 kV L/G		13.8 kV	9L12HAC015
12 kV L/G	13.8 kV	11.5 kV	9L28AGK472				
15 kV L/G		13.8 kV	9L28AGK572	Station Type			
				3 kV L/G	4.16 kV	2.4 kV	9L11MAB003
Distribution Type				4.5 kV L/G	4.8 kV	4.16 kV	9L11MAB004
3 kV L/G	4.16 kV	2.4 kV	9L24AFA108	6 kV L/G	6.9 kV	4.8 kV	9L11MAB006
6 kV L/G	6.9 kV	4.8 kV	9L24AFB108	7.5 kV L/G		6.9 kV	9L11MAB007
9 kV L/G	12.47 kV	6.9 kV	9L24AFC108	9 kV L/G	12.47 kV		9L11MAB009
10 kV L/G	13.8 kV		9L24AFD108	12 kV L/G	13.8 kV	11.5 kV	9L11MGB012
12 kV L/G		11.5 kV	9L24AFE108	15 kV L/G		13.8 kV	9L11MGB015
15 kV L/G		13.8 kV	9L24AFF108				

¹ This design is for protection of dry-type transformers.

Section 8

Equipment and Installation Information

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Equipment and Installation Information

INTRODUCTION

This section of the Application Guide provides basic construction information for POWER/VAC vacuum metalclad switchgear; a standard equipment specification, weights and dimensions, floor plan details, and installation details for floor, pad, or pier mounting.

Since POWER/VAC is a highly structured de-

sign, one basic floor plan detail, with three sets of dimensions, provides complete floor plan information, regardless of rating. Control and power conduit entrances remain in one specified location for all units in a lineup. In addition, anchor bolt locations are the same for each unit. These benefits of product design structuring simplify layout planning, site construction, and equipment installation.

STANDARD EQUIPMENT SPECIFICATION

GENERAL

This specification describes standard General Electric POWER/VAC vacuum metalclad switchgear rated 5 and 15 kV, 250 MVA through 1000 MVA. For definition of standard options (not described in this specification), see Section 6 of this guide.

other than the switchgear and essential customer connections.

INDUSTRY STANDARDS

POWER/VAC metalclad switchgear is designed, built and tested in accordance with applicable ANSI, IEEE and NEMA standards.

DOCUMENTATION

Standard documentation consists of the following computer-generated diagrams and documents:

- Device summary
- Elementary diagram (power and control circuits showing each wire and terminal point)
- Connection diagram (shows physical location of devices and wiring connection points)
- Interconnection diagram (shows interunit wiring)
- Arrangement drawing (includes one-line diagram, front view, and floor plan)

Standard documentation does *not* include side views, special drawing formats, special nomenclature for terminal points, special location or sequencing of customer terminal points, or preparation of composite drawings showing equipment

SERVICE CONDITIONS

POWER/VAC metalclad switchgear assemblies are suitable for operation at their standard nameplate ratings (See ANSI-C37.20.):

- Where ambient temperature is not above 40 C or below -30 C (104 F and -22 F)
- Where the altitude is not above 1000 meters (3300 feet)
- Where the effect of solar radiation is not significant

CONSTRUCTION

Indoor Equipment

Indoor POWER/VAC switchgear consists of one or more vertical sections which are mounted side-by-side and connected electrically and

mechanically to form a complete switching equipment.

Each vertical section is a self-supporting structure consisting of a bolted steel frame with reinforcing gussets. Assembled to this frame are front doors and top, side and rear covers. The external covers and doors are 11-gauge (or equivalent thickness) steel.

A vertical section will accommodate a maximum of two circuit breakers or three potential transformer, control power transformer or fuse rollout trays or certain combinations of these as defined in Section 6 of this guide.

Two front doors are mounted on each vertical section. Each door is provided with a full-length hinge, door stop, and two knurled-knob closing screws. Mounted on each breaker door are only those control, instrumentation and protection devices associated with the breaker in that compartment. Fuse blocks, terminal blocks and other surface-mounted accessories will be mounted in locations designed for that purpose within the associated breaker compartment.

Breakers are removable from the equipment by means of a portable lifting device. As a breaker is removed, grounded metal safety shutters isolate the primary contacts from the rest of the compartment.

Primary compartments of each circuit are isolated by grounded metal barriers which have no intentional openings. (The primary compartments are the breaker compartment, main bus compartment, power termination compartment, and auxiliary compartment.) In addition, each breaker and rollout tray is furnished with a 1/8-inch thick front plate that isolates the control from the primary compartment. Secondary-control circuit wires are armored or enclosed in grounded metal troughs where they pass through primary compartments.

Power termination compartments are located at the rear of the equipment, and are accessible through bolted covers. Barriers and a cable pass-through box are furnished to separate the two termination compartments in each vertical section when required. (See Section 6 for typical power-conductor compartment arrangements.)

Ventilation is provided by inlet openings through slots in the bottom flange of each front

door and louvres in the rear covers. Exhaust is through "basket weave" openings in the top covers (not used for power or control cable entry). Top exhaust vents are equipped with dust guards to keep dirt off the top breaker.

Outdoor Equipment

Weatherproof construction begins with basic indoor equipment and is partly provided by gasketing the end and rear covers, adding filters to ventilation louvres, and adding a sloped weatherproof roof. In addition, weatherproof doors (or a maintenance aisle) are added to the front of the equipment, a three-inch box frame is provided under each vertical section, and the equipment is painted for outdoor service.

Convection air flow is assisted by heaters, applied at half voltage for extended life, which provide 75 watts for each breaker and cable compartment, totaling 300 watts per vertical section. These heaters remain energized at all times (no switch or thermostat is provided) to guard against internal condensation when wide ambient temperature excursions occur.

AISLELESS CONSTRUCTION — For aisleless construction, full-height, gasketed, doors (with padlocks) are provided on the front of the basic weatherproofed equipment to protect the device doors. Grounded 120-volt convenience outlets are provided on each device door. In addition, a light socket and switch (120 volt, 100 watt) for an incandescent lamp is mounted on the inside of each weatherproof door.

PROTECTED-AISLE CONSTRUCTION — A pre-assembled weatherproof aisle of 11-gauge steel is added to the basic weatherproofed equipment to provide protected-aisle convenience. Doors with padlocks and panic latches are located at each end of the aisle. Space (full vertical section-sized) is provided at the left end of the lineup to allow for device door swing of the left-end units and can be used for a work area, batteries and battery charger, or for equipment storage.

Inlet ventilation openings for the aisle are louvred, equipped with filters, and located on the aisle doors. Exhaust is through screened openings designed into the roof overhang.

Equipment and Installation Information

A grounding-type receptacle, rated 250 volts ac, 20 amperes, is provided at each end of the aisle for portable comfort heaters. (Comfort heaters to be furnished by Purchaser.) A 120-volt grounding, duplex convenience outlet and a three-way switch for ceiling lights are also provided at each end of the aisle. Ceiling mounted light sockets for 120-volt, 100-watt, incandescent bulbs are furnished (one per vertical section).

COMMON-AISLE CONSTRUCTION — To provide common-aisle construction, the aisle between facing lineups of weatherproofed gear is spanned by a weatherproof roof. Space is provided at the left end of each lineup to allow for device-door swing. Otherwise, all construction details are the same as those for protected-aisle construction.

HARDWARE

All standard hardware will be high tensile-strength steel which is zinc plated and irridite dipped to resist corrosion.

BREAKER COMPARTMENT

Each POWER/VAC circuit breaker rolls on horizontal guide rails and has self-coupling primary and secondary contacts. A manually operated jackscrew racking mechanism is provided in each breaker compartment to move the breaker between the "connected" and "test/disconnected" positions. The equipment is of closed-door-drawout design, to allow the breaker to be racked between positions with the front door closed.

Grounded-metal safety shutters are actuated to cover the stationary primary disconnects when the breaker is moved from the connected position.

AUXILIARY COMPARTMENT

Rollout trays are provided in primary auxiliary compartments for mounting potential transformers (PT's), control power transformers (CPT's) or CPT fuses. Two trays can be accommodated in the bottom primary auxiliary compartment and one in the top compartment.

Potential transformers are General Electric Type JVM-3 and JVM-5, mounted three per tray for single-fused potential transformers and two per tray for double-fused potential transformers.

Control power transformers are General Electric epoxy-cast, V-8, dry-type transformers. A rollout tray can accommodate one single-phase 15-kVA control power transformer maximum. Larger control power transformers are stationary-mounted in the power termination compartment and only the fuses are mounted on a rollout tray.

POWER/VAC switchgear is provided with mechanical interlocks to:

- Prevent moving the breaker to or from the "connected" position when the breaker contacts are in the "closed" position;
- Prevent closing the breaker unless the primary disconnects are fully engaged or the breaker is in the test/disconnect position.
- Automatically discharge the closing springs when the breaker is moved between the "connected" and "test" positions or when it is inserted into or withdrawn from the compartment.

In addition, the breaker racking mechanism is a jackscrew type which positively holds the breaker when it is in either the "connected" or "test/disconnected" position. Finally, control power transformer primary fuses, whether located on the CPT or on separate rollout trays, are not accessible unless the CPT primary and secondary circuits are open.

Additional safety design features include:

- The rating interference plate which allows only a breaker of the correct type and rating to be inserted into any specific breaker compartment;
- Closed-door drawout design which allows breaker racking to and from the "connected" position with the front door closed;
- Grounded, metal safety shutters which automatically close to cover the stationary primary disconnects when the breaker is moved from the "connected" position.

MAIN BUS

The main bus is completely enclosed by grounded, metal barriers and feeds both the upper and lower compartment in a vertical section. Standard main bus materials are ASTMB 317

aluminum alloy No. 6101 for 1200-ampere rating (1/4-inch by 6-inch bar) and 2000-ampere rating (1/2-inch x 6-inch bar), and ASTM-B187 Type ETP copper for the 3000-ampere rating (2-3/8-inch x 6-inch bars). All main bus joints are silver plated and utilize at least two 1/2-inch zinc-plated, iridite-dipped steel bolts per joint. Provision for future extension of the main bus is standard.

Bus bars are mounted edgewise on 11-inch centers and are insulated with flame retardant, track-resistant epoxy applied by the fluid-dip process to a thickness that withstands the dielectric tests specified in ANSI-C37.20. The bus bars are supported on track-resistant, molded-polyester-glass supports which also serve as interstack bus barriers. Bus supports have strength suitable to withstand the forces caused by a peak short-circuit asymmetrical current of 80,000 amperes, (50,000 symmetrical amperes). All bus joints are insulated with pre-formed vinyl boots secured by nylon hardware.

Porcelain insulation to ground is provided standard for 15-kV main bus. This includes porcelain inserts in the bus-support barriers, porcelain stand-off insulators where required, and porcelain sleeves for the stationary primary disconnects.

SECONDARY CONTROL

Door-mounted Devices

Protection, instrumentation, and control devices, which provide indication or manual control, are mounted on the enclosure front doors.

The devices required for a particular breaker are mounted only on the compartment door associated with that breaker. For cases in which all devices cannot be accommodated on the breaker compartment door, the additional devices are mounted on the auxiliary compartment door in the same vertical section. (Only one breaker is furnished in a vertical section in such cases.)

Typical door-mounted devices are relays, meters, instruments, control switches, indicating lights, and test blocks. Standard POWER/VAC switchgear utilizes pre-engineered door-mounted device packages (called PIC packages) with specified available options for all basic circuit-protection schemes and uses preassigned locations on the door for these devices.

Equipment-mounted Devices

Secondary control devices which are not door-mounted are surface-mounted in their predesignated locations in the equipment. Included in this class are fuse blocks, terminal blocks, some auxiliary relays, and stationary auxiliary switches. Terminal blocks are one-piece, molded General Electric Type EB-25. All control circuits are properly protected using General Electric dead-front drawout mounted fuses.

Ring-type current transformers are mounted over the stationary primary disconnect bushings and are accessible through the front of the breaker compartment. Wound primary CT's, when required, are mounted in the power termination compartment. Potential transformers, and their associated fuses, are mounted on rollout trays.

Two "a" and three "b" contacts are wired from the breaker-mounted auxiliary switch for the Purchaser's use.

Wiring

Secondary control wiring is No. 14, extra-flexible, stranded, tinned-copper control wire, Type SIS (Vulkene), rated 600 volts, except for some specific circuits for which a larger wire size is required. Crimp-type, uninsulated spade terminals are furnished on all wire ends, except where non-insulated ring terminals are used to connect to fuse blocks, instrument studs or terminal block points which have two or more wire connections. Secondary control wires are armored or enclosed in grounded metal troughs where they pass through primary compartments.

POWER TERMINATION COMPARTMENT

Cable termination compartments for incoming and load cables are located at the rear of the equipment and are accessible through bolted rear covers. Barriers and cable pass-through boxes of 11-gauge steel are provided to isolate the circuit terminations in the event there are two cable termination compartments in the same vertical section. Each termination compartment can accommodate up to two 750-MCM stress cones (or two potheads) per phase without the addition of a rear extension. Roof entrance bushings and connections to General Electric metal-enclosed bus are also available.

Equipment and Installation Information

As required, the power-termination compartment will be used for mounting stationary CPT's, wound-primary CT's, ground-sensor CT's, surge arrestors, and other auxiliary devices.

Standard POWER/VAC switchgear includes only NEMA drilling for terminations. Terminal lugs are not included.

GROUND BUS

A ground bus of 1/4-inch by 2-inch copper extends throughout the lineup with connections to each breaker grounding contact and each cable compartment ground terminal. All joints are silver-plated and are made with at least two 3/8-inch zinc-plated, iridite-dipped steel bolts per joint. Station ground-connection points are located in each end section.

EQUIPMENT HEATERS

On outdoor designs, moisture condensation is minimized through the use of Calrod® heating elements. A 75-watt heating element is located in each breaker or auxiliary compartment and each cable compartment with a total of 300 watts per vertical section. Heaters are applied at half-voltage for extended life and are protected by perforated metal guards to prevent inadvertent contact with the heater element.

Heaters should be energized at all times to guard against condensation caused by wide ambient temperature excursions; accordingly, no switch or thermostat is provided in the heater circuit.

Heaters are supplied as standard on outdoor designs.

FINISH AND PAINT

Indoor switchgear enclosure parts are given an iron-phosphate pre-treatment and one coat of ANSI 61, gray, phenolic-modified alkyd-zinc-chromate primer. After assembly, a finish coat of ANSI 61, gray, air-dried nitrocellulose lacquer is applied to all exterior surfaces.

Outdoor switchgear is given the same pre-treatment and primer coat as indoor equipment. After assembly, however, a coat of acrylic primer-sealer is applied. Then a finish coat of ANSI 61, gray, air-dried acrylic lacquer is applied to all aisle and weather-exposed surfaces. Finally, the switchgear is given an undercoat of corrosion-resistant compound.

A durable protective finish thickness of approximately two mils on indoor gear and three mils on outdoor gear is provided by these finish schedules.

UNIT NAMEPLATES

Provided on each unit door is a 4-3/8-inch by 1-inch lamicaid nameplate attached by two metal screws. Either black on white or white on black will be furnished, as specified (white on black if not specified by Purchaser), with the designated customer unit name engraved on the nameplate in 3/16-inch letters, two lines and sixteen letters per line, maximum. A blank nameplate will be provided if unit designations are not specified.

INSTALLATION INFORMATION

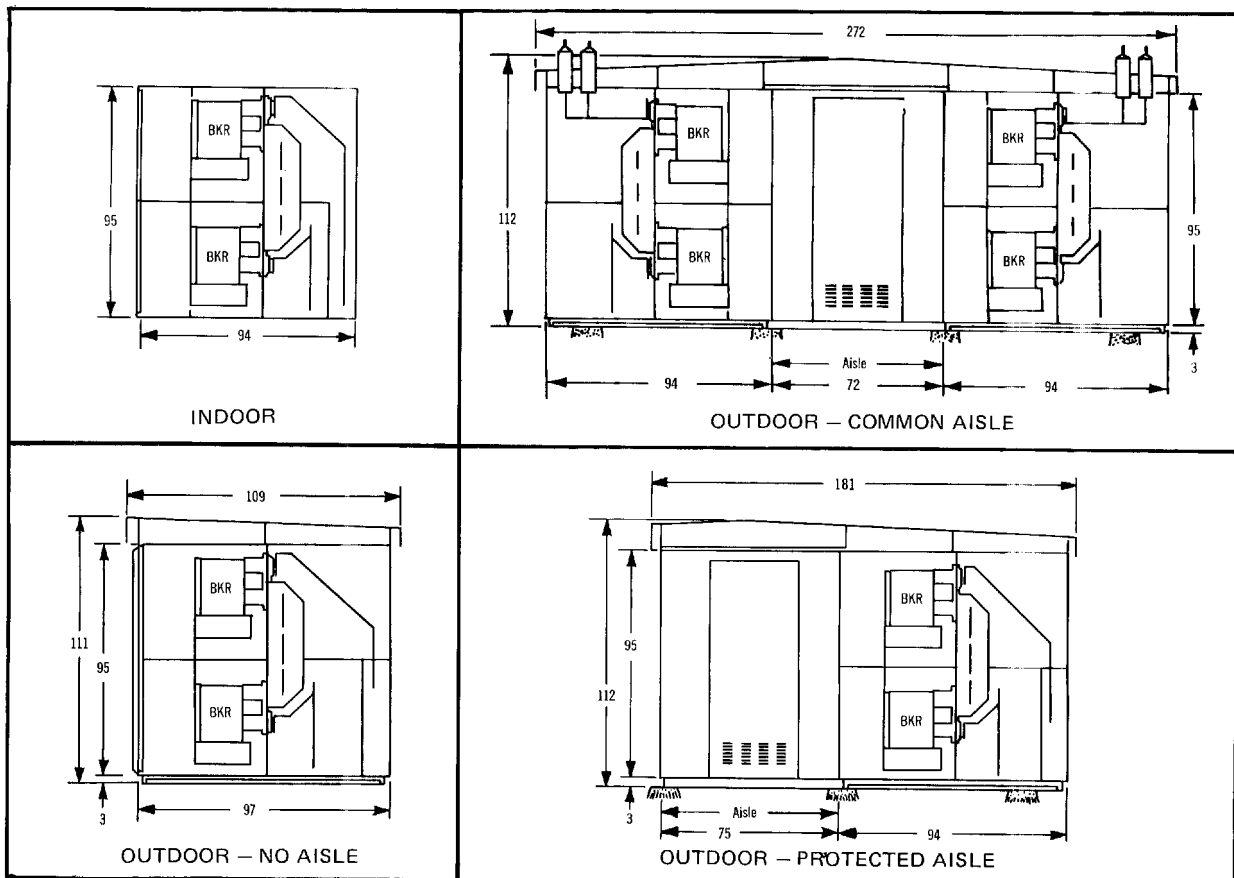
Layout planning and installation information for POWER/VAC switchgear equipment is detailed in Table 8-1 and Figures 8-1, 8-2 and 8-3. Typical weights and dimensions are given in Table 8-1 and Figure 8-1, respectively. Shown in Figure 8-2 are

floor plan details, including anchor bolt locations and power conductor and control conduit entrance locations. Equipment anchoring information is provided in Figure 8-3.

TABLE 8-1. Typical POWER/VAC Switchgear Weights (Pounds)

Breakers			Indoor Equipment		Outdoor Equipment			Roll-out Tray Weight (PT or CPT)
Breaker Type	Current Rating (Amperes)	Breaker Weights	Breaker Vertical Section Weight (Less Brkrs)	Auxiliary Vertical Section Weight (No Trays)	Breaker Vertical Section Weight (Less Brkrs)	Auxiliary Vertical Section Weight (No Trays)	Add for Protected Aisle (Per Vert. Section)	
VB-4.16-250	1200	550	3100	3100	3600	3600	1100	500
	2000	650						
VB-4.16-350	1200	550						
	2000	650						
	3000	780						
VB-7.2-500	1200	550						
	2000	650						
VB-13.8-500	1200	550						
	2000	650						
VB-13.8-750	1200	550						
	2000	650						
VB-13.8-1000	1200	550						
	2000	650						
	3000	780						

NOTE: For common aisle construction, add 1500 lbs. to the weight of two indoor vertical sections.

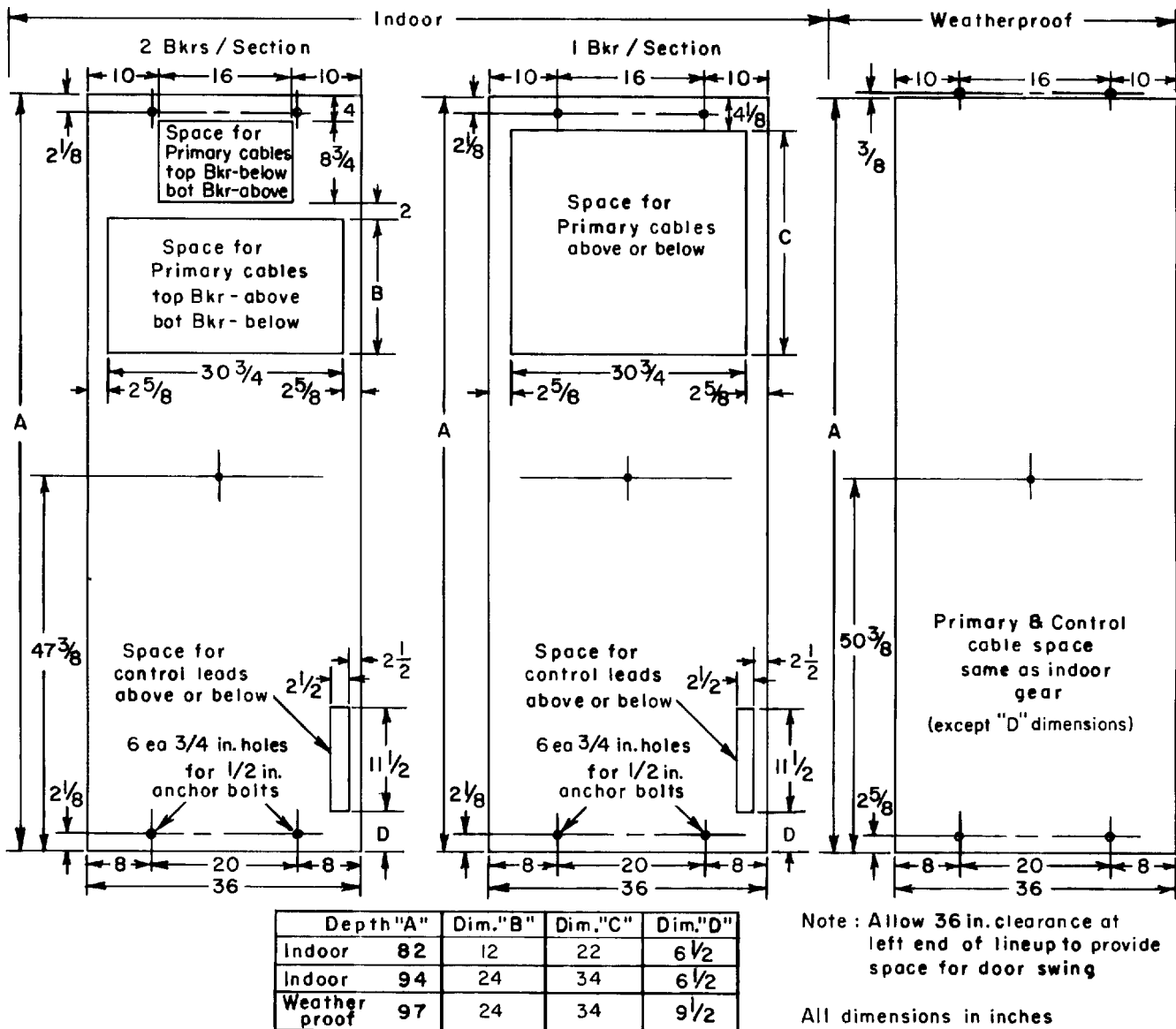


NOTE: Circuit breaker is approximately 33 inches high by 30 inches wide by 28 inches deep.

Figure 8-1. Typical dimensions (inches)

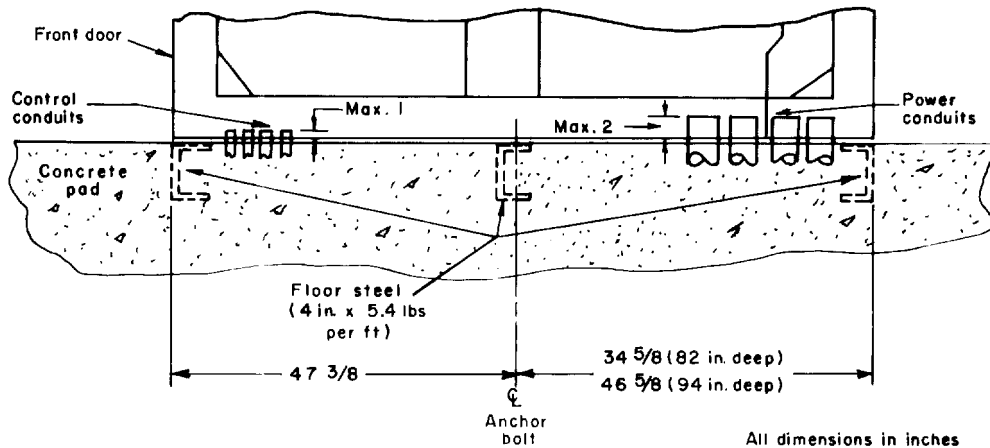
Equipment and Installation Information

Recommended minimum rear aisle: 26 inches

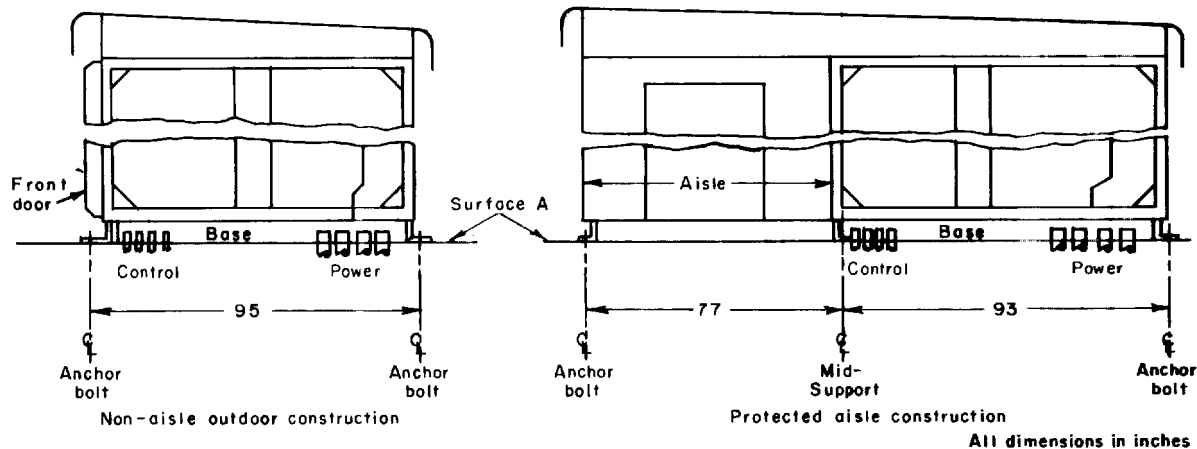


Recommended minimum front aisle: 66 inches

Figure 8-2. Floor plan details



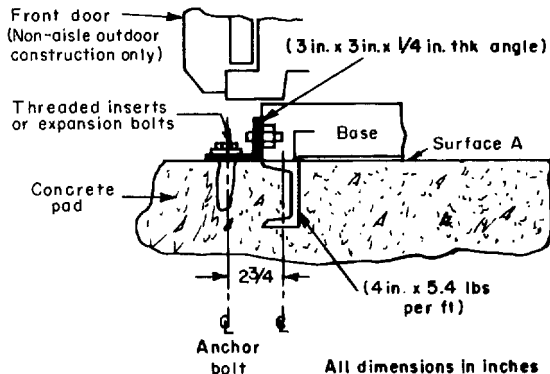
NOTE: All floor steel to be furnished by Purchaser. Floor steel members must be set level with each other, must be level over their entire length, and must be even with the level finish floor. The switchgear can be anchored to the floor steel by plug welds or 1/2-inch bolts furnished by Purchaser.



Switchgear support should be concrete or reinforced concrete with depth, fill, drainage, etc., according to recommended foundation design for the loading, type of construction, and local conditions involved. The base furnished with the switchgear should be supported level between "ends" and level over the full length.

Steel floor members to be furnished by Purchaser if required for leveling foundation and supporting switchgear.

Anchor bolts and clips should be used for anchoring the switchgear. The anchored clips are furnished with the switchgear. The Purchaser is to furnish the 5/8-inch threaded inserts or 5/8-inch expansion bolts.



NOTE: Surface A should be level with switchgear support and reasonably level and smooth for easy handling of power circuit breaker removable elements.

Figure 8-3. Equipment anchoring details for POWER/VAC metalclad switchgear.

Section 9

Custom Designed Equipment

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Custom Designed Equipment

INTRODUCTION

As described in Sections 6, 7, and 8 of this Application Guide, a wide variety of equipment configurations have been designed and pre-engineered for application to the most frequently required power switching functions. Specification,

selection and application of these pre-engineered equipments will provide the advantages of high quality, from repetitive manufacture, readily available error-free documentation, and faster shipping cycles at reasonable cost.

CUSTOM APPLICATIONS

Every effort has been made to pre-engineer equipments to serve most applications; however, some applications are not covered due to variations in power distribution system characteristics and

user operating procedure. For these applications, some of the units in a metalclad switchgear lineup may require custom design engineering and manufacturing effort.

EXAMPLES

Some examples of custom options are:

- Revenue metering compartments.
- Devices other than those listed in Section 7.
- Arrangement of door-mounted devices other than as shown in Section 6.
- Key interlocks.
- Special control power throw-over schemes.
- Special main bus arrangements (i.e., double bus in a single lineup).
- Special wiring, materials, construction features, paint color and/or processes, etc. other than those described in Section 8, "Standard Equipment Specification".
- Special drawings and drawing formats.

CUSTOM FEATURES

Specification of custom features will result in higher price and longer delivery so they should be avoided whenever possible. If an application

demands such features, requirements should be referred to the Switchgear Business Department for evaluation.

Section 10

Guide Form Specifications

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Guide Form Specifications

INTRODUCTION

Upon completion of the one-line diagram and the layout of the equipment lineup, the specifier may use the following guide to prepare his purchase specifications. The form is completed by circling the appropriate ratings and filling in the blanks.

For the specifier's convenience, the following pages illustrate the content of the specification guide applicable to the available pre-engineered, medium-voltage switchgear assemblies. In addition, this guide form specification is suitable for specifying

either vacuum or air-magnetic metalclad switchgear.

Please note that air-magnetic outdoor (non-aisle) and common aisle equipments are not pre-engineered designs; even though these guide form specifications may be used to specify air-magnetic outdoor (non-aisle) and common aisle switchgear, device locations and number of units required may not be the same as for pre-engineered equipment.

POWER/VAC outdoor (non-aisle) and common aisle equipments are pre-engineered designs.

SWITCHGEAR SPECIFICATIONS

GENERAL

The (indoor), (outdoor)*, (protected aisle), (common aisle)* metalclad switchgear described in this specification is intended for use on a (2400-volt) (4160-volt) (4800-volt) (6900-volt) (13,800-volt), three-phase, (three-wire) (four-wire), (grounded) (ungrounded) 60-Hz system. The switchgear shall be rated (4160-volts) (7200-volts) (13,800-volts) and shall have removable-element (air-magnetic) (vacuum) circuit breakers. The enclosure and circuit breaker, either individually or as a unit, shall have a basic impulse rating of (60 kV) (95 kV). The switchgear, including circuit breakers, meters, relays, etc. shall be factory tested.

APPLICABLE STANDARDS

The switchgear equipment covered by these specifications shall be designed, tested, and assembled in accordance with the latest applicable standards of ANSI, IEEE, and NEMA.

STATIONARY STRUCTURE

The switchgear shall consist of () breaker units and () auxiliary units assembled to form a rigid, self-supporting, completely metal-enclosed structure. Outdoor metalclad switchgear shall be enclosed in a weatherproof enclosure and shall include: suitable weatherproof access doors or doors with provision for padlocking; protected openings for ventilation as required; interior lighting and utility outlets with protective devices; and equipment heaters with protective devices. In each unit, the major parts of the primary circuit, such as the circuit breaker, buses, potential transformers, and control power transformers shall be com-

pletely enclosed by grounded metal barriers. This shall include an inner barrier in front of, or a part of, the circuit breaker.

ARRANGEMENT

The switchgear shall include the units as shown on the attached one-line diagram.

CIRCUIT BREAKER COMPARTMENT

Each circuit breaker compartment shall be designed to house (4160-volt) (7200-volt) (13,800-volt), removable-element circuit breakers. The stationary primary-disconnecting contacts shall be constructed of silver-plated copper. Grounded-metal safety shutters shall be provided which isolate all primary connections in the circuit breaker compartment when the breaker is withdrawn from the connected position.

CABLE COMPARTMENT

Cable termination facilities shall be provided as detailed in the descriptions. Where more than two 750 MCM cables per phase are terminated, a rear extension of the switchgear housing is acceptable. A 1/4-inch x 2-inches ground bus shall be furnished and shall be secured to each unit. It shall extend the entire length of the switchgear and shall be equipped with a terminal for connection to a ground system.

BUS COMPARTMENT

The main bus shall be rated (1200 amperes) (2000 amperes) (3000 amperes). Bus bars shall have a continuous current rating, in accordance with ANSI standards of temperature rise and

*See comments in introduction to this section.

Section 10

documented by design tests. All joints will be silver plated with at least two bolts per joint. Bus bars will be braced to withstand the magnetic stresses developed by currents equal to the main power circuit breaker close, carry, and interrupt ratings. The bus shall be provided with front access through removable panels.

FINISH

All steel surfaces shall be chemically cleaned and treated to provide a bond between the primer paint and metal surfaces. The switchgear exterior will be finished with air-dried acrylic lacquer paint of gray color (ANSI 61) for outdoor equipment or air-dried nitrocellulose lacquer paint of gray color (ANSI 61) for indoor equipment, unless otherwise specified.

CIRCUIT BREAKERS

The circuit breakers shall be rated (4160) (7200) (13-800)-volts, 60-Hz, with a continuous current rating of (1200) (2000) (3000)-amperes and a nominal interrupting rating of (250) (350) (500) (750) (1000) MVA. All circuit breakers of equal rating shall be interchangeable.

The circuit breaker shall be operated by an electrically charged, mechanically and electrically trip-free, stored-energy operating mechanism. Provision shall be included for manual charging of the mechanism and for slow closing of the contacts for inspection or adjustment.

The circuit breaker shall be equipped with secondary disconnecting contacts, which shall automatically engage in the operating positions.

The breaker compartment shall be furnished with a mechanism which will move the breaker between the operating and disconnect positions. The mechanism shall be designed so that the breaker will be self-aligning and will be held rigidly in the operating position without the necessity of locking bars or bolts. In the disconnect position, the breaker shall be easily removable from the compartment.

Interlocks shall prevent moving the breaker to or from the operating position unless its contacts are in the open position. As a further safety precaution, the operating springs shall be discharged automatically when the breaker is rolled fully into

the compartment or is moved into the disconnect position. Means shall be provided for padlocking the breaker in either the connected (operating) position or the disconnected position. When locked in the disconnected position, the breaker shall be removable from the compartment. Padlocking shall not interfere with operation of the breaker or its mechanism.

The circuit breaker control voltage shall be (48 volts dc) (125 volts dc) (250 volts dc) (115 volts ac 60-Hz) (230 volts ac 60-Hz).

INSTRUMENT TRANSFORMERS

Current Transformers

Current transformers shall have ratios and relay and metering accuracy as indicated in the details of each switchgear unit. The transformers shall have mechanical rating equal to the momentary rating of the circuit breakers, and shall be insulated for full voltage rating of the switchgear.

Potential Transformers

Potential transformers shall be drawout type, equipped with current-limiting fuses, and shall have an accuracy as required by the details of each switchgear unit. The ratio shall be as indicated in each switchgear unit specification.

CONTROL WIRING

Switchgear wire shall be No. 14 AWG minimum, Type SIS (Vulkene), tinned-copper wire.

DRAWINGS

Upon award of the contract, the manufacturer shall furnish drawings for (record) (approval and record). Drawings for approval shall include a front view, plan view, elementary diagram, and device summary. Drawings for record shall include the above information, plus wiring diagrams.

DEVICES

All protection, instrumentation, and control devices shall be General Electric type, as indicated, or equal.

Guide Form Specifications

GENERAL PURPOSE FEEDER (GPF)

BASIC UNIT

The metalclad switchgear for control of a feeder circuit shall contain:

- 1 — ~~(4160-volt)~~ ~~(7200-volt)~~ ~~(13,800-volt)~~ (air) (vacuum) power circuit breaker, (1200) (2000) amperes continuous, three-pole, with electrically operated, stored-energy mechanism.
- 1 — Set of insulated bus, three-phase, three-wire, (1200) (2000) (3000) amperes.
- 3 — Relays, phase overcurrent, Type IFC.
- 3 — Current transformers, single secondary, :5 ratio, Type JAG-0†.
- 1 — Switch, breaker control, Type SB-1.
- 2 — Indicating lamps, breaker open-close, red and green, Type ET-16.
- 1 — Breaker closing fuse block, pull-out type, two-pole, 30 amperes.
- 1 — Breaker tripping fuse block, pull-out type, two-pole, 60 amperes.
- 1 — Ammeter, indicating, Type AB-40.
- 1 — Switch, ammeter transfer, Type SB-1.
- 1 — Provisions for power conductor terminations. (NEMA drilling only. Lugs not included. For two 750 MCM cables per phase, maximum.)

DEVICE OPTIONS

- 1 — Relay, ground sensor overcurrent, instantaneous, Type HFC
 - or
 - Relay, ground sensor overcurrent, time-delay, Type IFC
 - or
 - Relay, overcurrent residual, Type IFC.
- 1 — Watthour meter Type DS-63
 - or
 - Watthour demand meter, Type DSM-63.
- 1 — Voltmeter, Type AB-40.
- 1 — Switch, voltmeter transfer, Type SB-1.
- 3 — Ammeters, Type AB-40 (in lieu of one ammeter and ammeter transfer switch).
- 1 — Relay, circuit breaker reclosing, Type NLR.
- 1 — Switch, reclosing relay cut-off, Type JBT.
- 1 — Test block current, Type PK-2.
- 1 — Test block, voltage, Type PK-2.
- 1 — Switch, permissive, Type SB-1 (in lieu of breaker control switch).
- 1 — Indicating lamp, breaker disagreement, Type ET-16.
- 1 — Switch, breaker position, Type SB-12. (For remote control.)
- 3 — Current transformers, single secondary, :5 ratio, Type JAG-0† (for bus differential).
- 3 — Current transformers, single secondary, :5 ratio, Type JAG-0† (for transformer differential).
- 1 — Current transformer, ground-sensor, 50:5 ratio, Tech-Tran.
- 3 — Surge arresters. (Optional on only air-magnetic switchgear.)

†Type JAG-0 is for vacuum switchgear. Use Type JAF-0 for air-magnetic switchgear.

BREAKER BYPASS FEEDER (BBF)[‡]

BASIC UNIT

The metalclad switchgear for control of a breaker by-pass feeder circuit shall contain:

- 1 — (4160-volt) (7200-volt) (13,800-volt) vacuum power circuit breaker, (1200) (2000) amperes continuous, three-pole, with electrically operated, stored-energy mechanism.
- 1 — Set of insulated bus, three-phase, three-wire, (1200) (2000) (3000) amperes.
- 1 — Space for power circuit breaker of same rating. Output terminals paralleled with output terminals of above breakers.
- 3 — Relays, phase overcurrent, Type IFC.
- 6 — Current transformers, single secondary, :5 ratio, Type JAG-0. (Three located on output terminals on each breaker position.)
- 2 — Switches, breaker control, Type SB-1.
- 4 — Indicating lamps, breaker open-close, two red and two green, Type ET-16.
- 2 — Breaker closing fuse block, pull-out type, two-pole, 30 amperes.
- 2 — Breaker tripping fuse block, pull-out type, two-pole, 60 amperes.
- 1 — Ammeter, indicating, Type AB-40. (Scale to match CT).
- 1 — Switch, ammeter transfer, Type SB-1.
- 1 — Provisions for power conductor terminations. (NEMA drilling only. Lugs not included. For two 750 MCM cables per phase, maximum.)

DEVICE OPTIONS

- 1 — Relay, ground-sensor overcurrent, instantaneous, Type HFC.
or
Relay, ground sensor overcurrent, time-delay, Type IFC
or
Relay, residual overcurrent, Type IFC
- 1 — Watthour meter, Type DS-63
or
Watthour demand meter, Type DSM-63.
- 1 — Voltmeter, Type AB-40.
- 1 — Switch, voltmeter transfer, Type SB-1.
- 3 — Ammeters, Type AB-40 (in lieu of one ammeter and ammeter transfer switch).
- 1 — Relay, circuit breaker closing, Type NLR.
- 1 — Switch, reclosing relay cut-off, Type JBT.
- 1 — Test block, current, Type PK-2.
- 1 — Test block, voltage, Type PK-2.
- 2 — Switch, permissive Type SB-1 (in lieu of breaker control switch).
- 2 — Indicating lamp, breaker disagreement, Type ET-16.
- 2 — Switch, breaker position, Type SB-12. (For remote control.)
- 3 — Current transformers, single secondary, :5 ratio, Type JAG-0 (for bus differential).
- 3 — Current transformers, single secondary, :5 ratio, Type JAG-0 (for transformer differential).
- 1 — Current transformer, ground-sensor, 50:5 ratio, Tech-Tran.

[‡]Breaker Bypass Feeder (BBF) is not available in air-magnetic switchgear.

Guide Form Specifications

TRANSFORMER PRIMARY FEEDER (TPF)

BASIC UNIT

The metalclad switchgear for control of a transformer primary feeder circuit shall contain:

- 1 — (4160-volt) (7200-volt) (13,800-volt) (air) (vacuum) power circuit breaker, (1200) (2000) amperes continuous, three-pole, with electrically operated, stored-energy mechanism.
- 1 — Set of insulated bus, three-phase, three-wire, (1200) (2000) (3000) amperes.
- 3 — Relays, phase overcurrent, Type IFC.
- 3 — Relays, transformer differential, Type STD.
- 1 — Relay, lockout, Type HEA.
- 1 — Relay, auxiliary, transformer sudden pressure, Type HAA.
- 3 — Current transformers, single secondary, :5 ratio, Type JAG-0†.
- 3 — Current transformers, single secondary, :5 ratio, Type JAG-0† (for transformer differential).
- 1 — Switch, breaker control, Type SB-1.
- 3 — Indicating lamps; breaker close-open, lock-out; red, green, and white, Type ET-16.
- 1 — Breaker closing fuse block, pull-out type, two-pole, 30 amperes.
- 2 — Breaker tripping and lockout fuse block, pull-out type, two-pole, 60 amperes.
- 1 — Ammeter, indicating, Type AB-40.
- 1 — Switch, ammeter transfer, Type SB-1.
- 1 — Provisions for power conductor terminations. (NEMA drilling only. Lugs not included. For two 750 MCM cables per phase, maximum.)

DEVICE OPTIONS

- 1 — Relay, ground-sensor overcurrent, instantaneous, Type HFC.
or
Relay, ground sensor overcurrent, time-delay, Type IFC
or
Time overcurrent residual relay, Type IFC.
- 1 — Watthour meter, Type DS-63
or
Watthour demand meter, Type DSM-63.
- 1 — Voltmeter, Type AB-40.
- 1 — Switch, voltmeter transfer, Type SB-1.
- 3 — Ammeters, Type AB-40 (in lieu of one ammeter and ammeter transfer switch).
- 1 — Test block, current, Type PK-2.
- 1 — Test block, voltage, Type PK-2.
- 1 — Switch, permissive, Type SB-1 (in lieu of breaker control switch).
- 1 — Indicating lamp, breaker disagreement, Type ET-16.
- 1 — Switch, breaker position, Type SB-12. (For remote control.)
- 3 — Current transformers, single secondary, :5 ratio, Type JAG-0† (for bus differential).
- 1 — Current transformer, ground-sensor, 50:5 ratio, Tech-Tran.
- 3 — Surge arresters. (Optional on only air-magnetic switchgear.)

†Type JAG-0 is for vacuum switchgear. Use Type JAF-0 for air-magnetic switchgear.

SINGLE SOURCE INCOMING LINE (SSIL)**BASIC UNIT**

The metalclad switchgear for control of an incoming line shall contain:

- 1 — (4160-volt) (7200-volt) (13,800-volt) (air) (vacuum) (1200) (2000) (3000) amperes continuous, three-pole, with electrically operated, stored-energy mechanism.
- 1 — Set of insulated bus, three-phase, three-wire, (1200) (2000) (3000) amperes.
- 3 — Relays, phase overcurrent, Type IFC.
- 3 — Current transformers, single secondary, :5 ratio, Type JAG-0†.
- 2 — Potential transformers, Type JVM.
- 4 — Fuses, Type EJ-1.
- 1 — Switch, breaker control, Type SB-1.
- 2 — Indicating lamps, breaker close-open, red and green, Type ET-16.
- 1 — Breaker closing fuse block, pull-out type, two-pole, 30 amperes.
- 1 — Breaker tripping fuse block, pull-out type, two-pole, 60 amperes.
- 1 — Ammeter, indicating, Type AB-40.
- 1 — Switch, ammeter transfer, Type SB-1.
- 1 — Voltmeter, Type AB-40.
- 1 — Switch, voltmeter transfer, Type AB-40.
- 1 — Provisions for power conductor terminations. (NEMA drilling only. Lugs not included. For two 750 MCM cables per phase, maximum.)

DEVICE OPTIONS

- 1 — Relay, time overcurrent residual, Type IFC
or
Relay, ground overcurrent Type IFC (transformer neutral).
- 1 — Watthour meter, Type DS-63
or
Watthour demand meter, Type DSM-63.
- 3 — Ammeters, Type AB-40 (in lieu of one ammeter and ammeter transfer switch).
- 1 — Wattmeter, indicating, Type AB-40.
- 1 — Varmeter, indicating, Type AB-40.
- 1 — Relay, underfrequency, Type SFF.
- 1 — Relay, power directional, Type CCP.
- 1 — Relay, undervoltage, Type NGV
or
Relay, phase sequence, Type ICR.
- 3 — Relays, transformer differential, Type STD.
or
Relays, bus differential, Type PVD.
- 1 — Relay, lockout, Type HEA.
- 1 — Relay, lockout, Type HEA.
- 3 — Current transformers, single secondary, :5 ratio, Type JAG-0† (for transformer differential).
- 3 — Current transformers, single secondary, :5 ratio, Type JAG-0† (for bus differential).
- 1 — Auxiliary relay, transformer sudden pressure, Type HAA.
- 2 — Relay, time delay, Agastat.
- 1 — Relay, negative sequence (blown fuse), Type NBV.
- 1 — Relay, transformer ground differential, Type IFD and auxiliary CT.
- 1 — Test block, current, Type PK-2.
- 1 — Test block, voltage, Type PK-2.
- 1 — Switch, permissive, Type SB-1 (in lieu of breaker control switch).
- 3 — Indicating lamp, breaker disagreement, lockout, Type ET-16.
- 1 — Switch, breaker position, Type SB-12. (For remote control.)
- 2 — Lockout fuse blocks, pull-out type, two-pole, 60 amperes.
- 3 — Surge arresters. (Optional on either vacuum or air-magnetic switchgear.)

†Type JAG-0 is for vacuum switchgear. Use Type JAF-0 for air-magnetic switchgear.

Guide Form Specifications

DUAL SOURCE INCOMING LINE (DSIL)

BASIC UNIT

The metalclad switchgear control of an incoming line shall contain:

- 1 — (4160-volt) (7200-volt) (13,800-volt) (air) (vacuum) power circuit breaker, (1200) (2000) (3000) amperes continuous, three-pole, with electrically operated, stored-energy mechanism.
- 1 — Set of insulated bus, three-phase, three-wire, (1200) (2000) (3000) amperes.
- 3 — Relays, phase overcurrent, Type IFC.
- 3 — Relays, directional phase overcurrent, Type JBC.
- 3 — Current transformers, single secondary, :5 ratio, Type JAG-0†.
- 1 — Switch, breaker control, Type SB-1.
- 2 — Indicating lamps, breaker close-open, red and green, Type ET-16.
- 1 — Breaker closing fuse block, pull-out type, two-pole, 30 amperes.
- 1 — Breaker tripping fuse block, pull-out type, two-pole, 60 amperes.
- 1 — Ammeter, indicating, Type AB-40.
- 1 — Voltmeter, Type AB-40.
- 1 — Switch, voltmeter transfer, Type AB-40.
- 1 — Provisions for power conductor terminations. (NEMA drilling only. Lugs not included. For two 750 MCM cables per phase, maximum.)

†Type JAG-0 is for vacuum switchgear. Use Type JAF-0 for air-magnetic switchgear.

DEVICE OPTIONS

- 2 (3) — Potential transformers, Type JVM.
- 4 (3) — Fuses, Type EJ-1.
- 1 — Relay, time overcurrent residual, Type IFC or
Relay, ground overcurrent Type IFC (transformer neutral).
- 3 — Relays, directional phase overcurrent, Type IBC (in lieu of 3-JBC's).
- 1 — Relay, directional ground overcurrent, Type IBCG.
- 1 — Watthour meter, Type DS-63 or
Watthour demand meter, Type DSM-63.
- 3 — Ammeters, Type AB-40 (in lieu of one ammeter and ammeter transfer switch).
- 1 — Wattmeter, indicating, Type AB-40.
- 1 — Varmeter, indicating, Type AB-40.
- 1 — Relay, underfrequency, Type SFF.
- 1 — Relay, power directional, Type CCP.
- 1 — Relay, undervoltage, Type NGV or
Relay, phase sequence, Type ICR.
- 3 — Relays, transformer differential, Type STD. or
Relays, bus differential, Type PVD.
- 1 — Relay, lockout, Type HEA. (For STD or PVD.)
- 1 — Relay, lockout, Type HEA. (For CCP and SFF.)
- 3 — Current transformers, single secondary, :5 ratio, Type JAG-0† (for transformer differential).
- 3 — Current transformers, single secondary, :5 ratio, Type JAG-0† (for bus differential).
- 1 — Auxiliary relay, transformer sudden pressure, Type HAA.
- 2 — Relay, time delay, Agastat.
- 1 — Relay, negative sequence (blown fuse), Type NBV.
- 1 — Relay, current balance, Type IJC.
- 1 — Test block, current, Type PK-2.
- 1 — Test block, voltage, Type PK-2.
- 1 — Switch, permissive, Type SB-1 (in lieu of breaker control switch).
- 3 — Indicating lamp, breaker disagreement, lockout, Type ET-16.
- 1 — Switch, breaker position, Type SB-12. (For remote control.)
- 2 — Lockout fuse blocks, pull-out type, two-pole, 60 amperes.
- 3 — Surge arresters. (Optional on either vacuum or air-magnetic switchgear.)

BUS ENTRANCE UNIT (BE)**BASIC UNIT**

The metalclad switchgear for a bus entrance shall contain:

- 1 — Set of insulated bus, three-phase, three-wire, (1200) (2000) (3000) amperes.
- 1 — Provisions for power conductor terminations. (NEMA drilling only. Lugs not included. For two 750 MCM cables per phase, maximum.)

DEVICE OPTIONS

- 3 — Current transformers, single secondary, :5 ratio, Type JAG-0†.
- 1 — Watthour meter, Type DS-63
or
Watthour demand meter, Type DSM-63.
- 1 — Voltmeter, Type AB-40.
- 1 — Switch, voltmeter transfer, Type SB-1.
- 1 — Ammeter, indicating Type AB-40
and
1 — Switch, ammeter transfer, Type SB-1.
or
3 — Ammeters, Type AB-40.
- 1 — Test block current, Type PK-2.
- 1 — Test block voltage, Type PK-2.
- 2 or 3 — Potential transformers, Type JVM.
- 4 or 3 — Fuses, Type EJ-1 (PT primary).
- 3 — Surge arresters. (Optional on either vacuum or air-magnetic switchgear.)

BUS TIE UNIT (BT)**BASIC UNIT**

The metalclad switchgear for control of a bus-tie circuit shall contain:

- 1 — (4160-volt) (7200-volt) (13,800-volt), (air) (vacuum) power circuit breaker, (1200) (2000) (3000) amperes continuous, three-pole, with electrically operated, stored-energy mechanism.
- 1 — Set of insulated bus, three-phase, three-wire, (1200) (2000) (3000) amperes. (Includes necessary bus-tie conductors.)
- 1 — Switch, breaker control, Type SB-1.
- 2 — Indicating lamps, breaker close-open, red and green, Type ET-16.
- 1 — Breaker closing fuse block, pull-out type, two-pole, 30 amperes.
- 1 — Breaker tripping fuse block, pull-out type, two-pole, 60 amperes.
- 3 — Current transformers, single secondary, :5 ratio, Type JAG-0†.
- 1 — Ammeter, indicating, Type AB-40.
- 1 — Switch, ammeter transfer, Type SB-1.

†Type JAG-0 is for vacuum switchgear. Use Type JAF-0 for air-magnetic switchgear.

DEVICE OPTIONS

- 2 — Lockout fuse blocks, pull-out type, two-pole, 60 amperes.
- 3 — Ammeters, indicating, Type AB-40, (in lieu of one ammeter and ammeter transfer switch).
- 1 — Test block, current, Type PK-2
and
1 — Test block, voltage, Type PK-2.
or
2 — Test blocks, voltage, Type PK-2.
- 1 — Switch, permissive, Type SB-1 (in lieu of breaker control switch).
- 1 — Indicating lamp, breaker disagreement, Type ET-16.
- 1 — Switch, breaker position, Type SB-12. (For remote control.)
- 6 — Current transformers, single secondary, :5 ratio, Type JAG-0† (for bus differential).
- 6 — Relays, bus differential, Type PVD.
- 2 — Relays, lockout, Type HEA.
- 2 — Indicating lamps, lockout, bus differential, Type ET-16.
- 3 — Current transformers, single secondary, :5 ratio, Type JAG-0† for "current summing".

Guide Form Specifications

INDUCTION MOTOR FEEDER (IMFE)

BASIC UNIT

The metalclad switchgear for local control and full-voltage-start of an induction motor for essential service shall contain:

- 1 — (4160-volt) (7200-volt) (13,800-volt), (air) (vacuum) power circuit breaker, (1200) (2000) amperes continuous, three-pole, with electrically operated, stored-energy mechanism.
- 1 — Set of insulated bus, three-phase, three-wire, (1200) (2000) (3000) amperes.
- 3 — Current transformers, single secondary, :5 ratio, Type JAG-0†.
- 1 — Switch, breaker control, Type SB-1.
- 2 — Indicating lamps, breaker close-open, red and green, Type ET-16.
- 1 — Breaker closing fuse block, pull-out type, two-pole, 30 amperes.
- 1 — Breaker tripping fuse block, pull-out type, two-pole, 60 amperes.
- 1 — Ammeter, indicating, Type AB-40.
- 1 — Current transformer, 50:5 ratio, ground-sensor, Tech-Tran.
- 1 — Relay, ground-sensor overcurrent, instantaneous, Type HFC.
- 3 — Relays, phase overcurrent, Type IFC66.
- 1 — Relay, overtemperature alarm, Type HGA.
- 1 — Provisions for power conductor terminations. (NEMA drilling only. Lugs not included. For two 750 MCM cables per phase, maximum.)

DEVICE OPTIONS

- 1 — Switch, permissive, Type SB-1 (in lieu of breaker control switch) (for remote control).
- 1 — Relay, lockout, Type HEA (for remote control).
- 1 — Indicating lamp, lockout, Type ET-16 (for remote control).
- 1 — Switch, breaker position, Type SB-12. (For remote control.)
- 1 — Lockout fuse block, pull-out type, two-pole, 60 amperes (for remote control).
- 1 — Test block, current, Type PK-2.
- 1 — Test block, voltage, Type PK-2.
- 1 — Switch, ammeter transfer, Type SB-1.
- 1 — Wattmeter, indicating, Type AB-40.
- 1 — Varmeter, indicating, Type AB-40.
- 3 — Current transformers, single secondary, :5 ratio, Type JAG-0† (for bus differential).
- 1 — Indicating lamp, breaker disagreement, Type ET-16.
- 1 — Watthour meter, Type DS-63
or
Watthour demand meter, Type DSM-63.

†Type JAG-0 is for vacuum switchgear. Use Type JAF-0 for air-magnetic switchgear.

INDUCTION MOTOR FEEDER (IMF1)**BASIC UNIT**

The metalclad switchgear for local control and full-voltage-start of an induction motor shall contain:

- 1 — (4160-volt) (7200-volt) (13,800-volt) (air) (vacuum) power circuit breaker, (1200) (2000) amperes continuous, three-pole, with electrically operated, stored-energy mechanism.
- 1 — Set of insulated bus, three-phase, three-wire, (1200) (2000) (3000) amperes.
- 3 — Current transformers, single secondary, :5 ratio, Type JAG-0†.
- 1 — Switch, breaker control, Type SB-1.
- 2 — Indicating lamps, breaker close-open, red and green, Type ET-16.
- 1 — Breaker closing fuse block, pull-out type, two-pole, 30 amperes.
- 1 — Breaker tripping fuse block, pull-out type, two-pole, 60 amperes.
- 1 — Ammeter, indicating, Type AB-40.
- 1 — Current transformer, 50:5 ratio, ground-sensor, Tech-Tran.
- 1 — Relay, ground-sensor overcurrent, instantaneous, Type HFC.
- 1 — Relay, thermal, 3-element, Type THC.
- 1 — Provisions for power conductor terminations. (NEMA drilling only. Lugs not included. For two 750 MCM cables per phase, maximum.)

DEVICE OPTIONS

- 1 — Switch, permissive, Type SB-1 (in lieu of breaker control switch). (For remote control.)
- 1 — Relay, lockout, Type HEA. (For remote control.)
- 1 — Indicating lamp, lockout, white, Type ET-16. (For remote control.)
- 1 — Switch, breaker position, Type SB-12. (For remote control.)
- 1 — Lockout fuse block, pull-out type, two-pole, 60 amperes (for remote control).
- 1 — Relay, machine differential, self-balance, Type HFC. (Requires three ring CT's located at machine. These CT's are *not* included in IMF-1 device package.)
- 1 — Test block, current, Type PK-2.
- 1 — Test block, voltage, Type PK-2.
- 1 — Relay, temperature, Type IRT.
- 1 — Switch, ammeter transfer, Type SB-1.
- 1 — Relay, instantaneous overcurrent, 3-element, Type HFC.
- 1 — Wattmeter, indicating, Type AB-40.
- 1 — Varmeter, indicating, Type AB-40.
- 3 — Current transformers, single secondary, :5 ratio, Type JAG-0† (for bus differential).
- 1 — Indicating lamp, breaker disagreement, Type ET-16.
- 1 — Watthour meter, Type DS-63
or
Watthour demand meter, Type DSM-63.
- 1 — Relay, undervoltage auxiliary, Type HFA (one per lineup).
- 1 — Relay, negative sequence (blown fuse), Type NBV (one per lineup).
- 1 — Relay, undervoltage, Type NGV (one per lineup).
- 1 — Relay, time-delay, Agastat (one per lineup).

†Type JAG-0 is for vacuum switchgear. Use Type JAF-0 for air-magnetic switchgear.

Guide Form Specifications

INDUCTION MOTOR FEEDER (IMF 2)

BASIC UNIT

The metalclad switchgear for local control and full-voltage-start of an induction motor with RTD's and self-balancing differential shall contain:

- 1 — (4160-volt) (7200-volt) (13,800-volt) (air) (vacuum) power circuit breaker, (1200) (2000) amperes continuous, three-pole, with electrically operated, stored-energy mechanism.
- 1 — Set of insulated bus, three-phase, three-wire, (1200) (2000) (3000) amperes.
- 3 — Current transformers, single secondary, :5 ratio, Type JAG-0†.
- 1 — Switch, breaker control, Type SB-1.
- 3 — Indicating lamps, breaker close-open (red and green) and lockout relay (white), Type ET-16.
- 1 — Breaker closing fuse block, pull-out type, two-pole, 30 amperes.
- 2 — Fuse blocks, breaker tripping and lockout, pull-out type, two-pole, 60 amperes.
- 1 — Ammeter, indicating, Type AB-40.
- 1 — Current transformer, ground-sensor, 50:5 ratio, Tech-Tran.
- 1 — Relay, ground-sensor overcurrent, instantaneous, Type HFC.
- 1 — Relay, lockout, Type HEA.
- 3 — Relays, phase overcurrent, Type IFC66.
- 1 — Relay, machine differential, self-balance, Type HFC. (Requires three ring CT's located at machine. These CT's are *not* included in the IMF-2 device package.)
- 1 — Relay, temperature, Type IRT.
- 1 — Provisions for power conductor terminations. (NEMA drilling only. Lugs not included. For two 750 MCM cables per phase, maximum.)

DEVICE OPTIONS

- 1 — Switch, permissive, Type SB-1 (in lieu of breaker control switch). (For remote control.)
- 1 — Switch, breaker position, Type SB-12. (For remote control.)
- 1 — Test block, current, type PK-2.
- 1 — Test block, voltage, Type PK-2.
- 1 — Switch, ammeter transfer, Type SB-1.
- 1 — Wattmeter, indicating, Type AB-40.
- 1 — Varmeter, indicating, Type AB-40.
- 3 — Current transformers, single secondary, :5 ratio, Type JAG-0† (for bus differential).
- 1 — Indicating lamp, breaker disagreement, Type ET-16.
- 1 — Relay, undervoltage auxiliary, Type HFA (one per lineup).
- 1 — Watthour meter, Type DS-63
or
Watthour demand meter, Type DSM-63.
- 1 — Relay, negative sequence (blown fuse), Type NBV (one per lineup).
- 1 — Relay, undervoltage, Type NGV (one per lineup).
- 1 — Relay, time delay, Agastat (one per lineup).
- 3 — Relays, machine differential, self-balance, Type CFD. (In lieu of HFC.)
- 3 — Current transformers, single secondary, :5 ratio, Type JAG-0†. (For use with CFD's.)

†Type JAG-0 is for vacuum switchgear. Use Type JAF-0 for air-magnetic switchgear.

SYNCHRONOUS MOTOR FEEDER (SMF 1)

The metalclad switchgear for control and full-voltage-start of a synchronous motor (smaller than 1500 hp) with direct connected or brushless exciter shall contain:

- 1 — (4160-volt) (7200-volt) (13,800-volt) (air) (vacuum) power circuit breaker, (1200) (2000) amperes continuous, three-pole, with electrically operated, stored-energy mechanism.
- 1 — Set of insulated bus, three-phase, three-wire, (1200) (2000) (3000) amperes.
- 1 — Relay, phase overcurrent, three-element, Type THC.
- 1 — Relay, ground-sensor, Type HFC.
- 1 — Relay, time delay, Agastat (incomplete sequence).
- 3 — Current transformers, single secondary, :5 ratio, Type JAG-0†.
- 1 — Current transformer, ground-sensor, 50:5 ratio, Tech-Tran.
- 1 — Switch, breaker control, Type SB-1.
- 2 — Indicating lamps, breaker close-open, red and green, Type ET-16.
- 1 — Breaker closing fuse block, pull-out type, two-pole, 30 amperes.
- 1 — Breaker tripping fuse block, pull-out type, two-pole, 60 amperes.
- 1 — Drilling and wiring for exciter field rheostat. (Rheostat shipped with motor and installed by Purchaser.)
- 1 — Ammeter, indicating, Type AB-40. (scale to match CT's.)
- 1 — Ammeter, field, Type DB-40.
- 1 — Field shunt. (For field ammeter.)
- 1 — Varmeter, Type AB-40.

With a direct-connected exciter, the field control shall consist of:

- 1 — Field control panel (for direct-connected exciter) consisting of:
 - 1 — Exciter relay, Type IC2820.
 - 1 — Field contactor, Type IC2812.
 - 1 — Field discharge resistor.
 - 1 — Field forcing resistor.
 - 1 — Rotor thermal device, Type IC2820.

- 1 — Auxiliary relay, Type HFA.
- 1 — Slip-guard relay, Type IC3655.
- 1 — Field application panel.

With a brushless exciter, the field control shall consist of:

- 1 — Field control panel (for brushless exciter with either shutdown or resynchronization on pull-out) consisting of:
 - 1 — Rectifier, Syntron, Type Y2080.
 - 1 — Voltpac, Type 9T92.
 - 1 — Discharge resistor.
 - 2 — Relays, time delay, Agastat.
 - 1 — Relay, starting protection, Type IFC. (This relay mounted on compartment door.)
 - 1 — Relay, field application, Type HGA.
 - 1 — Relay, slip-guard, Type IC3655.
- 1 — Provisions for power conductor terminations. (NEMA drilling only. Lugs not included. For two 750 MCM cables per phase, maximum.)

DEVICE OPTIONS

- 1 — Switch, permissive, Type SB-1 (in lieu of breaker control switch).
- 1 — Switch, breaker position, Type SB-12. (For remote control.)
- 1 — Test block, current, Type PK-2.
- 1 — Test block, voltage, Type PK-2.
- 1 — Wattmeter, indicating, Type AB-40.
- 1 — Watthour meter, Type DS-63
or
Watthour demand meter, Type DSM-63.
- 1 — Relay, negative sequence (blown fuse), Type NBV.
- 3 — Current transformers, single secondary, :5 ratio, Type JAG-0† (for bus differential).
- 1 — Switch, ammeter transfer, Type SB-1.
- 1 — Relay, undervoltage, Type NGV. (one per lineup.)
- 1 — Relay, time delay, Agastat (for undervoltage).
- 1 — Relay, undervoltage auxiliary, Type HFA.
- 1 — Relay, lockout, Type HEA. (For remote control.)
- 1 — Indicating lamp, breaker disagreement, Type ET-16.
- 1 — Relay, machine differential, self-balance, Type HFC. (Requires three ring CT's located at machine. These CT's are not included in SMF-1 device package.)

†Type JAG-0 is for vacuum switchgear.

Use Type JAF-0 for air-magnetic switchgear.

Guide Form Specifications

SYNCHRONOUS MOTOR FEEDER (SMF2)

BASIC UNIT

The metalclad switchgear for control and full-voltage-start of a synchronous motor (1500 hp or larger) with direct connected or brushless exciter shall contain:

- 1 — (4160-volt) (7200-volt) (13,800-volt), (air) (vacuum) power circuit breaker, (1200) (2000) amperes continuous, three-pole, with electrically operated, stored-energy mechanism.
- 1 — Set of insulated bus, three-phase, three-wire, (1200) (2000) (3000) amperes.
- 1 — Relay, phase overcurrent, three-element, Type THC.
- 1 — Relay, ground-sensor, Type HFC.
- 1 — Relay, machine differential, self-balance, Type HFC. (Requires three ring CT's located at machine. These CT's are *not* included in SMF-2 device package.)
- 1 — Relay, lockout, Type HEA. (For machine differential.)
- 1 — Relay, time delay, Agastat (incomplete sequence).
- 3 — Current transformers, single secondary, :5 ratio, Type JAG-0†.
- 1 — Current transformer, ground-sensor, 50:5 ratio, Tech-Tran.
- 1 — Switch, breaker control, Type SB-1.
- 2 — Indicating lamps, breaker close-open, red and green, Type ET-16.
- 1 — Breaker closing fuse block, pull-out type, two-pole, 30 amperes.
- 1 — Breaker tripping fuse block, pull-out type, two-pole, 60 amperes.
- 1 — Drilling and wiring for exciter field rheostat. (Rheostat shipped with motor and installed by Purchaser.)
- 1 — Ammeter, indicating, Type AB-40. (Scale to match CT's.)
- 1 — Ammeter, field, Type DB-40.
- 1 — Field shunt, (for field ammeter).
- 1 — Varmeter, Type AB-40.

With a direct-connected exciter the field control shall consist of:

- 1 — Field control panel (for direct-connected exciter) consisting of:
 - 1 — Exciter relay, Type IC2820.
 - 1 — Field contactor, Type IC2812.

†Type JAG-0 is for vacuum switchgear. Use Type JAF-0 for air-magnetic switchgear.

- 1 — Field discharge resistor.
- 1 — Field forcing resistor.
- 1 — Rotor thermal device, Type IC2820.
- 1 — Auxiliary relay, Type HFA.
- 1 — Slip-guard relay, Type IC3655.
- 1 — Field application panel.

With a brushless exciter, the field control shall consist of:

- 1 — Field control panel (for brushless exciter with either shutdown or resynchronization on pull-out) consisting of:
 - 1 — Rectifier, Syntron, Type Y2080.
 - 1 — Voltpac, Type 9T92.
 - 1 — Discharge resistor.
 - 2 — Relays, time delay, Agastat.
 - 1 — Relay, starting protection, Type IFC. (Mounted on compartment door.)
 - 1 — Relay, field application, Type HGA.
 - 1 — Relay, slip-guard, Type IC3655.
- 1 — Provisions for power conductor terminations. (NEMA drilling only. Lugs not included. For two 750 MCM cables per phase, maximum.)

DEVICE OPTIONS

- 1 — Switch, permissive, Type SB-1 (in lieu of breaker control switch).
- 1 — Switch, breaker position, Type SB-12. (For remote control.)
- 1 — Test block, current, Type PK-2.
- 1 — Test block, voltage, Type PK-2.
- 1 — Wattmeter, indicating, Type AB-40.
- 1 — Watthour meter, Type DS-63
- or
- Watthour demand meter, Type DSM-63.
- 1 — Relay, negative sequence (blown fuse), Type NBV.
- 3 — Current transformers, single secondary, :5 ratio, Type JAG-0† (for bus differential).
- 1 — Switch, ammeter transfer, Type SB-1.
- 1 — Relay, undervoltage, Type NGV (one per lineup).
- 1 — Relay, time delay, Agastat (for undervoltage).
- 3 — Relays, machine differential, Type CFD (in lieu of HFC).
- 1 — Indicating lamp, breaker disagreement, Type ET-16.
- 3 — Current transformers, single secondary, Type JAG-0†. For machine differential for use with Type CFD relays. (Requires 3 ring CT's located at machine. These CT's are not included in the SMF2 device package.)

GAS TURBINE OR DIESEL-GENERATOR (GEN)**BASIC UNIT**

The metalclad switchgear for generator control shall contain:

- 1 — (4160-volt) (7200-volt) (13,800-volt) (air) (vacuum) power circuit breaker, (1200) (2000) (3000) amperes continuous, three-pole, with electrically operated, stored-energy mechanism.
- 1 — Set of insulated bus, three-phase, three-wire, (1200) (2000) (3000) amperes.
- 3 — Relays, machine differential, Type CFD.
- 1 — Relay, lockout, Type HEA. (For machine differential.)
- 1 — Relay, time overcurrent, Type IFC (ground overcurrent protection).
- 1 — Relay, power directional, Type ICW.
- 3 — Current transformers, single secondary, :5 ratio, Type JAG-0†.
- 3 — Current transformers, single secondary, :5 ratio, Type JAG-0†. (For machine differential.)
- 3 — Relays, time overcurrent, voltage restraint, Type IJCV.
- 1 — Ammeter, indicating, Type AB-40.
- 1 — Wattmeter, indicating, Type AB-40.
- 1 — Varmeter, Type AB-40.
- 1 — Switch, breaker control, Type SB-1.
- 1 — Switch, ammeter transfer, Type SB-1.
- 1 — Switch, voltmeter (removable handle), Type SB-1.
- 1 — Switch, synchronizing (removable handle), Type SB-1.
- 1 — Switch, generator, Type SB-1.
- 2 — Indicating lamps, breaker open-close, red and green, Type ET-16.
- 1 — Indicating lamp, lockout relay, white, Type ET-16.
- 1 — Breaker closing fuse block, pull-out type, two-pole, 30 amperes.
- 1 — Breaker tripping fuse block, pull-out type, two-pole, 60 amperes.
- 1 — Generator governor fuse block, pull-out type, two-pole, 30 amperes.
- 2 — Potential transformers, Type JVM.
- 4 — Fuses, Type EJ-1. (PT primary.)
- 1 — Lockout fuse block, pull-out type, two-pole, 60 amperes.
- 1 — Provisions for power conductor terminations. (NEMA drilling only. Lugs not included. For two 750 MCM cables per phase, maximum.)

DEVICE OPTIONS

- 3 — Current transformers, single secondary, :5 ratio, Type JAG-0† (for bus differential).
- 1 — Indicating lamp, lockout relay, white, Type ET-16.
- 1 — Relay, voltage balance, Type CFVB.
- 1 — Relay, ground directional, Type ICC.
- 1 — Temperature meter, Type DB-40.
- 1 — Voltmeter, Type AB-40.
- 1 — Time meter, Type KT.
- 1 — Watthour meter, Type DS-63
- or
- Watthour demand meter, Type DSM-63.
- 1 — Frequency meter, Type AB-40.
- 1 — Synchronizing panel consisting of:
 - 2 — Voltmeters, Type AB-40.
 - 1 — Frequency meter, Type AB-40.
 - 1 — Synchroscope, Type AB-16.
 - 2 — Indicating lamps, for synchronizing, white, Type ET-16.
 (Only one synchronizing panel required per lineup.)
- 1 — Switch, temperature meter, Type SB-1.
- 1 — Relay, negative sequence, Type INC.
- 1 — Test block, current, Type PK-2.
- 1 — Test block, voltage, Type PK-2.
- 1 — Relay, loss-of-field, Type CEH.
- 1 or 2 — Potential transformers, Type JVM. (For generator regulator.)
- 2 or 4 — Fuses, Type EJ-1. (PT primary.)
- 1 — Current transformers, single secondary, :5 ratio, Type JAG-0† (for generator regulator).
- 3 — Surge arresters. (Optional on either vacuum or air-magnetic switchgear.)

†Type JAG-0 is for vacuum switchgear. Use Type JAF-0 for air-magnetic switchgear.

AUXILIARY COMPARTMENT

Auxiliary compartments shall be furnished (as required) to house the following devices:

- () Drawout potential transformers, Type JVM, with current-limiting fuses.
- () Drawout-mounted single-phase control power transformer, rated 120/240V, with current limiting fuses.
- () Stationary-mounted control power trans-

formers with drawout current-limiting primary fuses (2400-volts) (4160-volts) (7200-volts) (13,800-volts). kVA, (three-phase) (208Y/120V) (480Y/277V), (single-phase 120/240V) secondary.

- () Tripping battery and battery charger.
- () Power company metering (specify).
- () Instruments, meters and relays.

Section 11

Sample Proposal Documentation

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SAMPLE VACUUM METALCLAD SWITCHGEAR SPECIFICATION	11-3
SAMPLE BILL OF MATERIAL	11-4
SAMPLE FRONT ELEVATION AND PANEL ARRANGEMENT	11-6
SAMPLE FLOOR PLAN	11-7

Sample Proposal Documentation

INTRODUCTION

It is the objective of the General Electric Company to provide its customers quality documentation of the POWER/VAC Metalclad Switchgear product offering. Selection of pre-engineered equipment configurations enables early availability of drawings and bills of material for use in building

layout or construction planning. Early detailed definition also means minimum delivery cycles and maximum assurance of quality equipment.

Typical examples of POWER/VAC documentation are exhibited in the following pages.

INDEX TO PROPOSAL DRAWING

Customer Unit	GE Unit	Description
1,15	001A,B and 010A,B	Power Company Metering Units
2,14	002A,B and 009A,B	Incoming Line Units
3,4,12,13	003A,B and 008A,B	Synchronous Motor Feeders
5,6,7,8, 10,11	004A,B and 005A 006A and 007A,B	General Purpose Feeders
9	005B and 006B	Bus Tie Unit

GENERAL ELECTRIC COMPANY
SWITCHGEAR BUSINESS DEPARTMENT
VACUUM METALCLAD SWITCHGEAR SPECIFICATION

SPECIFICATIONS: VMC-123-45678
REVISION: 00
DATE: 06/29/76
CUSTOMER: ABC ELECTRIC COMPANY
PLANT/STATION: SUBSTATION Z-10
ENGINEER: John Doe

GENERAL DESCRIPTION

These specifications describe indoor, drawout, vacuum, metalclad switchgear, rated 13.8 kV, as proposed for operation on a solidly grounded system, rated 13,800 volts, line-to-line, three-phase, four-wire, 60 hertz.

APPLICABLE STANDARDS

The vacuum metalclad switchgear equipment covered by these specifications will be designed, tested, and assembled in accordance with the applicable standards of ANSI, IEEE, and NEMA.

DRAWINGS AND INSTRUCTION BOOKS

The following drawings of the switchgear will be furnished:

- Arrangement and floor plan drawings
- Elementary and wiring connection diagrams

Suitable instruction books will be shipped with the switchgear.

BUS RATING

The three-phase, insulated aluminum buses will have a continuous current rating of 2000 amperes.

POWER CIRCUIT BREAKERS

The power circuit breakers will be vacuum interrupter Type VB-13.8-500, 1200A, 125V dc stored energy closing, and 125V dc tripping.

CONTROL POWER

A 125V dc source for operation of electrical devices is not included.

CONSTRUCTION

Form SE-328† describes the general construction features of the metalclad switchgear. Form SE-329‡ shows typical section views of POWER/VAC metalclad switchgear.

ARRANGEMENT AND DETAIL SPECIFICATION INDEX

The units, when viewed from the control panel side of the structure, will be arranged in accordance with the front view drawing submitted with this specification.

†Form SE-328 contains the Standard Equipment Specification from Section 8 of this Application Guide.

‡Form SE-329 contains the typical section views shown in Figures 1-2, 1-4, and 1-5 of this Application Guide.

SAMPLE
PROPOSAL
DOCUMENTATION

11

Sample Proposal Documentation

GENERAL ELECTRIC
SUMMARY OF SWITCHGEAR EQUIPMENT

DEVICE SUMMARY OF METALCLAD EQUIPMENT-VAC

LINE-UP NO. 01		UNIT NO. 002A	
MK-QTY-DEV	LOC- DESCRIPTION	DEV NO	ORDERING NO.
		OR ABBR	
100 001	CIRCUIT BREAKER 52	VB-13.8-500-1200A	
110 003 ZA	JAG-O CURR TRAN CT	GE 750X10G510	
130 003 ZD	JAG-O DIFF TRAN CT	GE 750X10G510	
130 003 AA	AB PHASE OC RELAY 51/B	GE 12IFC53A1A	
	AC		
140 001 AD	RESIDUAL OC RLY 51N/B	GE 12IFC53A2A	
373 001 CA	BKR CONTROL SW CS	16SB1B9X2	
	3 STAGE		
37F 001 HA	AMMETER SWITCH AS	16SB1CA15X2	
37K 001 HD	VOLTMETER SW VS	16SB1CF11X2	
380 002	FB INDICATING LTS IL	GE 0116B6708G043	
38A 001	ET16 RED CAP	0208A3768P009	
38B 001	ET16 GREEN CAP	0208A3768P008	
400 001 CA	AMMETER AB-40 AM	GE 50103131LSSV2	
410 001 GD	VOLTMETER AB-40 VM	GE 50103021PZXE2	
7G2 001 1A	FUSE BLK 2P 30A FU	0673D0515421G01	
7G3 002 1B	TC FUSE BLK 2P 60A FU	0673D0515422G01	
003	PHASE OC RLY 50/51	GE 12IFC53B1A	
001	RESID OC RLY 51N	GE 12IFC53B2A	

REQ NO 123-45678

SQ NO 912345

ENGR JOHN DOE

SUMMARY NO 1234A1234 CONT ON SH D04 SH D03

DATE 06/29/76

REV NO 00

Figure 11-1. Sample bill of material of the POWER/VAC metalclad switchgear equipment.

GENERAL ELECTRIC
SUMMARY OF SWITCHGEAR EQUIPMENT

DEVICE SUMMARY OF METALCLAD EQUIPMENT-VAC

LINE-UP NO. 01		UNIT NO. 003A	
MK-	QTY-DEV LUC-	DESCRIPTION	DEV NO ORDERING NO. OR ABBR
100	001	CIRCUIT BREAKER	52 VB-13.8-500-1200A
110	003 ZA	JAG-O CURR TRAN	CT GE 760X10G504
171	001 ZE	GRD SENSOR TRAN	CT 15371-6
		TECH TRAN	
180	003 AA	AB PHASE OC RELAY	49/50 GE 12THC30A_A
	AC		
190	001 AD	GRD SENSOR RLY	50GS GE 12HFC11B1A
200	001 AJ	MOTOR DIFF RLY	87M GE 12HFC13B1A
210	001 AZ	HAND RESET L/O	86M GE 12HEA61B235X2
		RELAY	
220	001 AE	UNDERVOLT RLY	27 GE 12NCV13B29A
230	001 LA	AGASTAT TIMER	62 GE 7022PB
260	001 GF	WATTMETER AB-40	WM GE 50103221ARAS1DWC
280	001 GH	VARMETER AB-40	VAR GE 50103742AHSE1DMC
373	001 CA	BKR CONTRUL SW	CS 16SB1B9X2
		3 STAGE	
37F	001 HA	AMMETER SWITCH	AS 16SB1CA15X2
380	003	INDICATING LTS	IL GE 0116B6708G043
38A	001	ET16 RED CAP	0208A3768P009
38B	001	ET16 GREEN CAP	0208A3768P008
38D	001	ET16 WHITE CAP	0208A3768P005
400	001 GA	AMMETER AB-40	AM GE 50103131LSRX2
7G2	002 TA	TD FUSE BLK 2P 30A	FU 0673D0515421G01
7G2	002 TB	TC FUSE BLK 2P 60A	FU 0673D0515422G01
899	001	PROVISION FOR	NEMA DRILLING FUR
		CABLES	MAX. OF 2-750MCM
			CABLES PER PHASE

REQ NO 123-45678

SO NO 912345

ENGR JOHN DOE
DATE 06/29/76SUMMARY NO 1234A1234 CONT QN SH D06 SH D05
REV NO 00

Figure 11-2. Sample bill of material of the POWER/VAC metalclad switchgear equipment.



11-6

Section 11

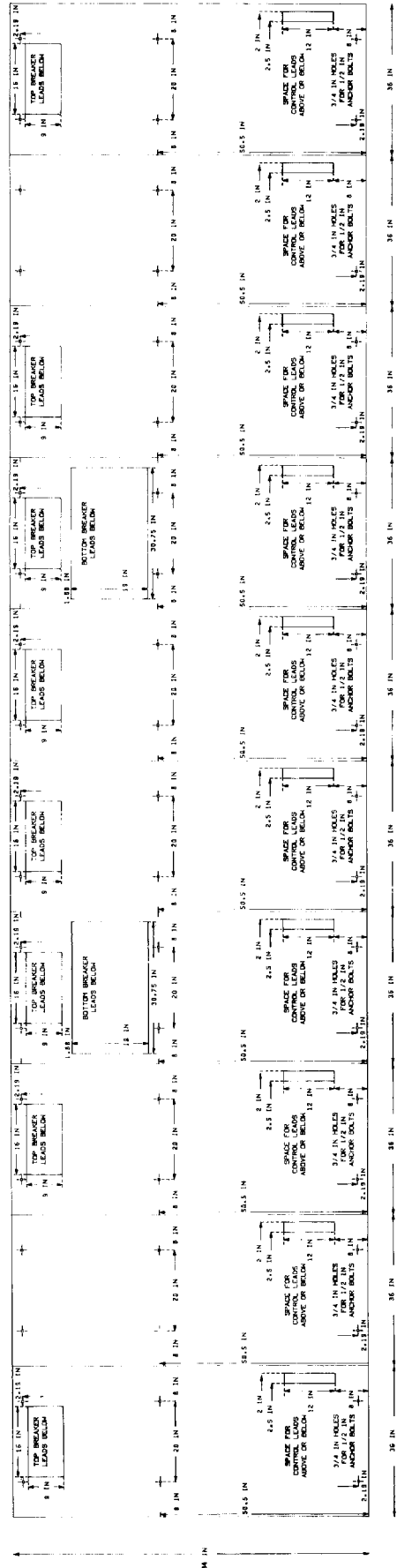


Figure 11-4. Sample floor plan.

1. OPEN / VAC
INCIDENTAL SWITCHGEAR
APPLICATION GUIDE

Switchgear Business Department • 6901 Elmwood Avenue • Philadelphia, PA 19142

GENERAL  ELECTRIC

GET-6600A
11-76 (12M)